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ENTOMOLOGICAL SURVEY OF HIMALAYA

PART XXVII.—PROF. MANI'S THIRD ENTOMOLOGICAL EXPEDITION TO THE NORTH-WEST (PUNJAB) HIMALAYA.*

By

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Received on 10th February 1958

I. INTRODUCTION

Accounts of two earlier Expeditions to the North-West Himalya during the summer of 1954 and 1955 were given by Mani.[1] The Third Expedition was also organised by him but he was unable to be with the Expedition throughout and I took over the leadership from him.[2] The Expedition spent about two months

* Parts I—XIV and XVII-XXI of this series appeared in *Agra University Journal of Research* (Science); parts XV & XVI in *Turtox News*; Parts XXII & XXIII are appearing in *Rec. Indian Mus.* and parts XXIV, XXV, XXVI are appearing in the *Linnean Society Journal.*

1. Mani, M. S. 1955. *Agra Univ. J. Res.* (Sci.), 4(1): 157-170; 1955 *Turtox News*, 33(1); 1956. *Turtox News*, 34(1).

   Mani, M. S. & Santokh Singh, 1955. *Agra Univ. J. Res.* (Sci.) 4 (Suppl.): 717-740.

2. Singh, Santokh. Third Entomological Expedition to the North-West Himalaya. *Turtox News*, 35 (8): 170-172, figs. 3.

Detailed technical papers on the collections will follow in subsequent parts.

studying the insect life beyond the timber-line. The team comprised in addition to the author, Messrs H. N. Baijal, V. K. Gupta of the School of Entomology, and Prof. Mani's son M. Viswanath, who had been members of the earlier Expeditions and Mr. R. L. Kotpal of the Zoology Department, Meerut College, Meerut, who was new to the Himalaya.

The main object this year was to explore the regions of the frozen *Sarkund Lake* (Dashair Lake) 4408 m. (14,500 ft.) to the west of Beas Rikhi Peak (4600 m. (18,134 ft.) on the Pir Panjal Range; the *Seragru Ice-Fall* 3800 m. (12,500 ft.) in the Kulti Nal and the *Sonapani Glacier*, *Seri Ice-Fall* 4560 m. (15,000 ft.) in the Purana Khoksar Nal (Main Himalaya).

The route followed by the Expedition is as follows :—

Stages	Distance in Kilometres
Agra to Pathankot (By railroad)	676·8
Pathankot to Baijnath (By road)	131·2
Baijnath to Mandi („)	80·0
Mandi to Kulu („)	68·8
Kulu to Manali* („)	36·8

* Trek from Manali onwards to North.

Manali 1976 m. (6,500 ft.) to Kote 2432 m. (8,000 ft.)	11·2
Kote to Rahla 2736 m. (9,000 ft.)	3·2
Rahla to Marhi 3496 m. (11,500 ft.)	5·6
Marhi to Camp I, 3648 m. (12,000 ft.)	0·8
Camp I to Sarkumd Lake 4408 m. (14,500 ft.)	4·0
Camp I to Rohtang Pass 4030 m. (13,300 ft.)	5·6
Rohtang Pass to Camp II 3496 m. (11,500 ft.)	8·0
Camp II to Khoksar	4·8
Khoksar to Kulti Nal	4·8
Kulti Nal to Camp III 3648 m. (12,000 ft.)	1·6
Camp III to Seragru Ice-Fall 3800 m. (12,500 ft.)	4·0
Camp III to Camp II via Khoksar	11·2
Camp II to Dhorni	6·4
Dhorni to Chhatru	8·0
Chhatru to Camp IV in Purana Khoksar Nal	1·6
Camp IV to Camp V on Sonapani Glacier 4560 m. (15,000 ft.)	4·8
Camp V to Camp VI 4408 m. (14,500 ft.) via Rohtang Pass	38·4

The Expedition left Agra with more than a ton of stores of scientific and mountaineering equipment and food supplies, on May 15, and reached Manali on the evening of May 17. The trek from Manali began on May 22 and Camp I was established on the evening of May 23. Prof M. S. Mani came up from Agra with some additional equipment and met us at this camp on May 28. Seeing the party well acclimatised and after giving last minute instructions, he went back on May 31. Owing to the fresh soft snow the original plan of crossing Rohtang Pass on May 31. had to be abandoned, and the night was therefore spent on the summit of the Pass, The supply Base (Camp II) was set up at about 3496 m. in the Chandra Valley on

June 1. From here advanced camps were pushed into Kulti Nal for exploring the Seragru Ice-Fall region and in the Purana Khoksar Nal for Sonapani Glacier. Altogether six camps were established and the party trekked a distance of about 195 kilometres in reaching these camps.

The following is a synopsis of the general programme of movement :--

Start of Expedition from Agra, May 15, 1956.

Start of Trek ... ... May 20

Reach Camp I ... ... May 21

Halt 22-24 May

Leave Camp I May 25

Reach Camp II ... ... --- May 25

Halt May 26-28

Leave Camp II May 29

Reach Camp III Kulti Nal Meadow ... May 31

Halt June 1-6

Leave Camp III June 7

Reach Camp IV, Gramphu Meadow below and north of Rohtang Pass, opposite Kulti Nal-Supply Base ... June 7

Leave Camp IV June 8

Reach Camp V Purana Khoksar Nal ... June 8

Halt 9-12 June

Leave Camp V June 13

Reach Camp VI Hamta Meadow ... ... June 13

Halt June 14 & 15

Leave Camp VI June 16

Return to Camp IV June 16

Halt June 17 and 18

Leave June 19

Return Camp 1 ... ... June 19

Halt June 20 & 21

While the general programme of the time table was adhered to according to schedule, the locations and numbers of camps had to be altered. Camps on Rohtang Pass and Hamta Meadow were cancelled and in place Sonapani Glacier and Sarkund Lake camps were established.

The following is the technical programme of research drawn up by Prof. M. S. Mani.

1. General faunistic survey of High Altitude Insect Life of N. W. Himalaya, especially beyond the timber-line (3000 m. above sea level). Collections of specimens from Ladakh, Zaskar and Lahaul-Spiti Ranges.
2. Study of general ecological conditions above the timber-line, with special reference to their bearing on insect life.
3. Study of the general habits and peculiarities of life-cycles of high altitude insects.
4. Observations on animal associations (with special reference to insects) at high altitudes and their inter-relationships.
5. Adaptations of insects for life at extreme high altitudes.
6. Zoogeography of the N. W. Himalaya.
7. Origin and evolution of High Altitude Insect Life.
8. Exploration in the frozen Lake region, Seragru Ice-Fall and Sonapani Glacier (Seri Ice-Fall)

Equipment.—Mountaineering and camping outfit comprised light single-fly tents, Meade tent, wind-break, sleeping bags, alpine suits, ice axes, crampons, ropes, cooking vessels and stoves. A part of the above was obtained by Prof. Mani from the Himalayan Club, Calcutta, on loan. The food supplies included considerable amount of tinned material donated by G. G. Industries, Agra; Nestle's Calcutta, Polson's Bombay and Stanes, Coimbatore. The scientific equipment included in addition to entomological collecting and preserving materials, altimeter, soil thermometer and other thermometers, compass, pedometer, barometer, current meter, cameras, etc.

II. AREA SURVEYED

The area surveyed by the Third Expedition constitutes parts of Lahaul and the Pir Panjal Range. Lahaul Valley is a part of the Kulu Subdivision of Kangra District, Punjab, and lies between 32° - 8′ to 32° - 59′ North Latitude and 76°—49′ to 77° - 47′ East Longitude. To the south is the Bara Bangahal, to the east lies the Spiti Valley; to the north the Ladakh Province of Kashmir and on the west is the Chamba District of Himachal Pardesh. The southern boundry is formed by the great Pir Panjal Range, which is crossed by Rohtang Pass 4030 m. and Hamta Pass 4250 m. above sea level to get into the valley (Fig. 1). The eastern side is bounded by an off-shoot of the Great Himalayan Range and acts as a water-parting between the river Chandra and river Spiti. This water-parting is crossed by Kanzam Pass 3424 m. To the north, the area is bounded by the Zaskar Range while to the west the Great Himalayan Range continues. The mass of the Great Himalayan Range between R. Chandra and R. Bhaga (with an average elevation of 5500 m.) constitutes an unexplored part of Lahaul. The Great Himalayan Range in the triangle formed by rivers Chandra and Bhaga has many peaks rising above 6000 m. (Fig. 2), and its numerous lateral valleys are filled with glaciers. It is one great ice-sheet torn here and there by lofty heights of impassable rock and snow. The most important peak, though not the highest is the Gaphan Shreckhorn (Phantom Cone) Peak 5832 m. This peak can be seen in fair weather from Kulu Valley through a gap in the Pir Panjal.

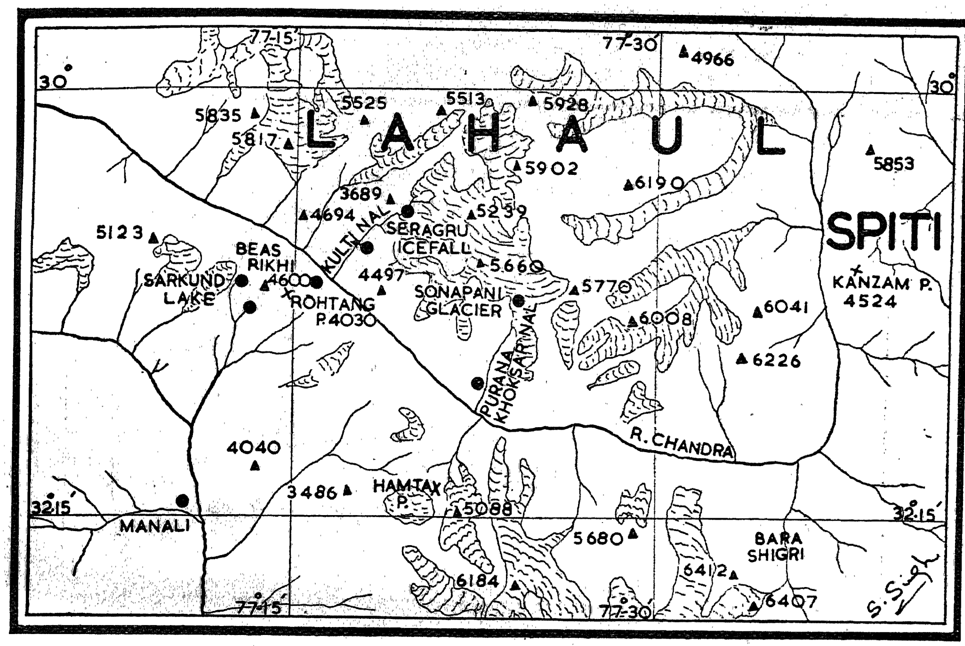


Fig. 1. Sketch map of Lahaul-Spiti, showing river Chandra, chief glaciers, streams and the more important peaks. The Camp sites of the Expedition are indicated in black circles.

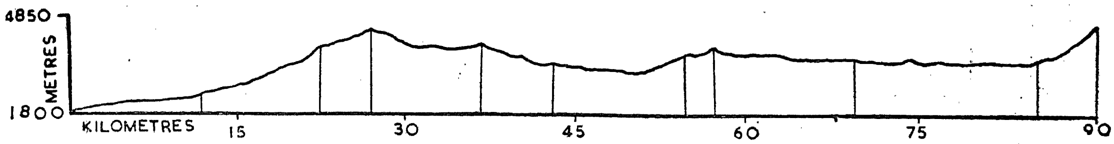


Fig. 1-A. Vertical section of the route followed by the Third Entomological Expedition from Manali, a distance of nearly 90 kilometres shown on horizontal axis. The altitudes are indicated on the vertical axis.

Lahaul has three parts; first the Valley of Chandra locally called Rangoli; the second Valley of Bhaga called Gara and the third the Patan or Valley of Upper Chenab.

Glaciers.—There are many glaciers, ranging from 11 to 19 kilometres in length (Table 1. Fig. 1.) Bara Shigri Glacier is perhaps the most noted one in Lahaul. It enters R. Chandra at the bend of the river from the south, and originates from the northern slope of the Great Pir Panjal Range. It is nearly 3·2 kilometres wide and its snout almost runs down to the river. In 1836 the glacier spread across the river and dammed it up, causing what is known as the cataclysm of the Chandra. Signs of the resulting destruction are still to be seen throughout Lahaul, Other important glaciers of the region are shown below.

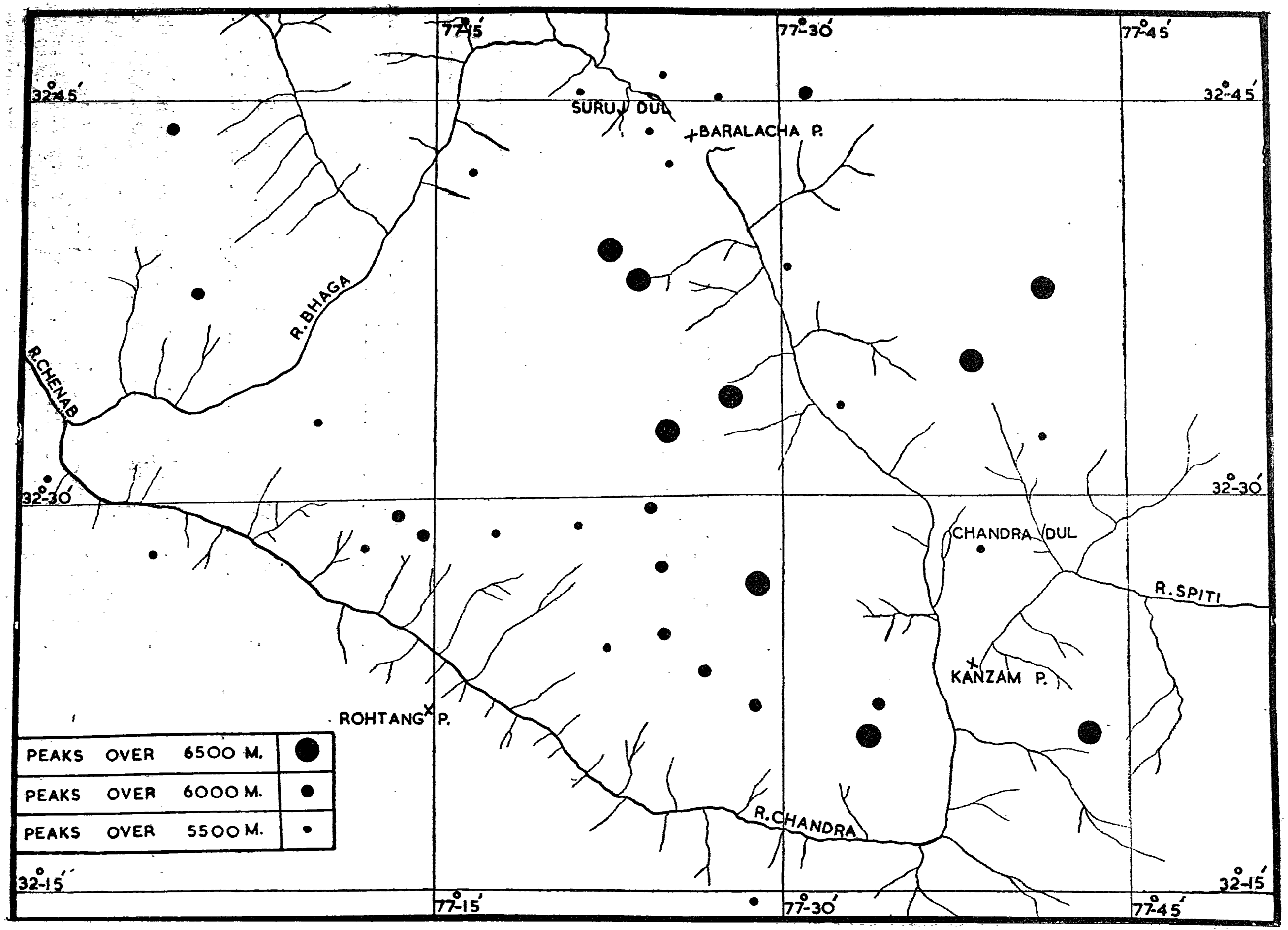


Fig. 2. Sketch map of Lahaul-Spiti showing the courses of the rivers, locations of important peaks and lakes.

TABLE I

Showing The Main Glaciers And The Rivers Fed By Them

No.	Name of the glacier			Length in Kilometres	River into which it drains
1.	Tuan	...	...	16	Chenab
2.	——			14·5	,,
3.	Sisu	...	...	11·2	Chandra
4.	Sonapani	...	...	11·2	,,
5.	———			16·0	,,
6.	Bara Shigri	...	...	——	,,
7.	Milang	...	...	11·2	Bhaga

Rivers Chandra and Bhaga and their courses.—The rivers Chandra and Bhaga rise on opposite sides of Baralacha Pass 4862 m (Fig. 3), within about 1·6 kilometres from one an other, the Chandra on the south-east and the Bhaga on the north-west. Chandra rises from a great snow field and is a stream of considerable magnitude from its very inception. For the first 120 kilometres its valley is entirely uninhabited. It passes through an almost barren area with lofty mountains clad in eternal snow on its either sides. It runs in a south-easterly direction upto about a distance of 88 kilometres, when it suddenly turns to the north-west and after passing through the Bara Shigri and a course of about 185 kilometres it joins up with the river Bhaga at Tandi at an altitude of 3200 m above sea level. Its fall from its source to Tandi averages only about 13 m per kilometre.

Bhaga has a course of about 105 kilometres to Tandi and its fall is almost double that of Chandra. For the first 50 kilometres its valley resembles that of Chandra. It is in this valley, some 7 kilometres up the river from Tandi, that Keylang, the principal village and the capital of Lahaul is situated.

After their junction at Tandi the Chandra and Bhaga flow as River Chenab in a north-westerly direction with a fall of about 5-6 m per kilometre. At Thirot about 25 kilometres below Tandi it enters Chamba. Chenab valley is considerably wide at places and some forests of *Pinus excelsa* are met with. The slopes are comparatively gentle and barley, potato and a medicinal herb locally called *Kuth* are cultivated in many villages.

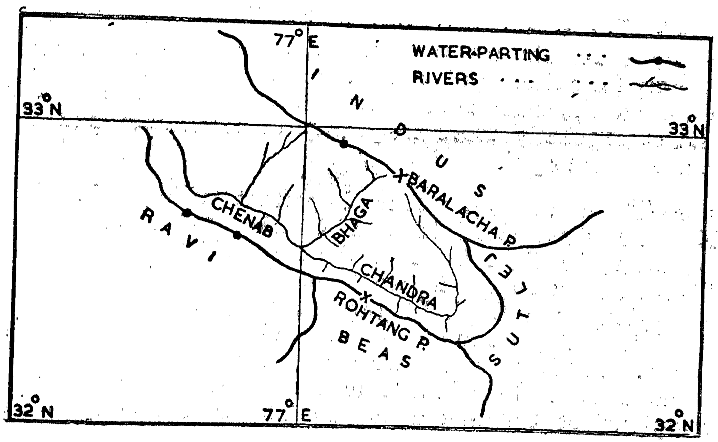


Fig. 3. Sketch map of Lahaul-Spiti showing the water-partings between the rivers Bhaga, Chandra, Chenab and Indus to the north, Sutlej to the east and Beas and Ravi to the south.

Lakes.—There are three lakes in Lahaul. Lake Chandar Dul near the Kanzam Pass, more than a kilometre long and of considerable depth, is situated at an elevation of 4420 m above mean sea level. It is fed by springs and melting snow from the adjoining peaks, and the surplus water drains into river Chandra (Fig. 2). The lake Suraj Dul is fed by Bhaga about 1·6 kilometres from its source, and is about 2·5 kilometres in diameter. This lake is situated at an elevation of 4850 m above mean sea level. The river emerges from the lake on the opposite side to continue its journey to Tandi in a south-westerly direction. The third lake Sarkund is situated on the Pir Panjal Range to the west of Beas Rikhi Peak; a detailed description is given in the following pages.

Passes :—The following are some of the more frequented passes :—

TABLE II

Statement Showing The Important Passes And The Areas With Which They Establish Communication.

No.	Name	Altitude in metres	Direction	Range on which situated	Area with which communicates
1.	Rohtang	4030	South	Pir Panjal	Kulu
2.	Hamta	4250	,,	,,	,,
3.	Asha Gali	5100	South-west	,,	Bara Bangahal
4.	Kukti	5011	,,	,,	Chamba
5.	Kanzam	4524	East	Spur of Gr. Himalaya	Spiti
6.	Palmo	...	,,	,,	,,
7.	Baralacha	4862	North	Great Himalaya	Ladakh
8.	Shingo La	5066	North-west	,,	,,

All these passes remain under snow for the greater part of the year and become passable only for a short period in the late summer. Of these Rohtang and Baralacha lie on the trade route between Kulu, Ladakh and further north in Central Asia, and consequently more frequently used. Hamta and Kanzam are frequented by traders from Spiti.

Rest Houses—There are only four important villages in the Chandra valley viz, Khoksar, Sisu, Gondhla and Ghoshal Out of these the first three are situated on the right bank of the river while last named is on the left side. Ghoshal is the largest village in whole of the Lahaul. The Bhaga valley is dotted with Keylang (the Capital), Jispa, Patseo, Sumdeo and Darcha, while the Chenab part of the valley has more and larger villages of Tandi, Lote, Shansha, Jalma, and Thirot. P. W. Rest Houses are available at Khoksar, Sisu, Gondhla, Keylang, Jaspa and Patseo. In addition to these rest houses a new R. H. has recently been completed at Chhatru about 20 kilometres above Khoksar in the Chandra Valley.

Routes.—Lahaul is reached from Kulu Valley by two routes over the Pir Panjal Range. The more important of the two is through Rohtang Pas 4030 above mean sea level. The mule track descends into the Chandra Valley to Khoksar at a distance of 10 kilometres from Rohtang. There is a P. W. D. Rest House on the left bank of the river Chandra. The river is crossed by a suspension bridge and the mule track on right bank of the river connects with the rest house at Sisu, 15 kilometres down the river. The river flows partly into a shallow lake below Sisu. Thirteen kilometres further down the mule track passes through Gondhla, where there is a Rest House on the right side of the river. Tandi (the confluence of R. Chandra and R. Bhaga) is nearly 10 kilometres down from Gondhla. At this place the track bifurcates, one branch going up the river Bhaga and the other follows the course of river Chenab along its right bank. The latter continues along the river for about 40 kilometres to Thirot, passing through the villages Lote, Shansha, and Jalma. Keylang about 6 kilometres above Tandion Bhaga is the head-quarters of the Government Offices, has a Rest House and a High School on the right bank. Beyond Keylang the road lies on the left bank and passes through the villages of Jaspa, Darcha and Patseo, all of which have Rest Houses. Crossing then over to the left bank one proceeds up the stream to Zingzingbar (4242 m) above sea level Crossing back to the right bank the path leads to Baralacha Pass about 105 kilometres from Tandi. From Baralacha lies the route to Leh and Tibet.

The route to Spiti bifurcates from the Rhotang-Khoksar road, just below the Rohtang Pass in the Chandra Valley and proceeds up the left bank of the river. About 18 kilometres upstream there is a bridge over Chandra at Chhatru and a Rest House. The route now lies on the right side, which is still under construction. When completed it will unite Lahaul with the valley of Spiti. In the meanwhile an old route along the left bank is used. From Chhatru the route reaches the Kanzam Pass about 30 kilometres further up after crossing the Bara Shigri Glacier. On the other side of the Pass is the Spiti Valley. Before the Kanzam Pass the route branches off up the Chandra Valley to Baralacha Pass. An alternative route from Kulu Valley is by the Hamta Pass which joins at Chhatru. This is a shorter route but remains under snow for a longer time and is therefore less frequented than the Rohtang.

Climate.—The elevation, latitude and the huge wall of the Great Pir Panjal Range which serves as an effective barrier to the water laden monsoon currents from the Indian Ocean are the major factors which determine the climate of the region. Practically all the moisture is precipitated to the south of this range, and whatever manages to escape through some of the valleys and passes to the north is deposited mostly in the form of snow. The average rainfall (including the winter snow-fall) at Keylang is about 150 mm. For the greatest part of the year the whole valley remains under a thick blanket of snow, often from 9 to 12 metres thick at some places. The summer is very short and comes late. Snow persists as late as late May or early June in the vicinity of Khoksar at an elevation of 3200 m above mean sea level. The average altitude of the valley is about 3100 m. Mean annual temperature of the valley recorded at Kardong (opposite Keylang in the Bhaga Valley at an elevation of 3300 m) is 7·2° C. Mean temperature of different months is given below :—

March	—	7·7°C
June	...	15·0°C
September	...	7·0°C
December	...	1·6°C

At higher elevations, about 4560 m on Sonapani Glacier, the minimum temperature recorded -10·0°C was during the middle of June 1956. Even in summer water freezes at many places. Owing to the great rarefaction of the atmosphere both insolation and radiation are rapid. Evaporation from exposed surfaces is also extremely rapid. General atmospheric conditions are predominantly cold and arid. The aridity is the most important single factor besides intense cold, which determines the quantity and quality of vegetation, At higher elevations cold, dry and fierce wind is another factor responsible for the absence of tall vegetation.

III. LOCALITIES VISITED

Sarkund Lake (Dashair Lake) 4408 m.—(About 32°0′ N. Latitude and 77°25′ E. Longitude) This is a small lake situated in a narrow saddle almost on the crest line in the Pir Panjal Range to the west of the Beas Rikhi Peak (4600 m.). The lake remains frozen for greatest part of the year. In late June it was still mostly frozen with only patches of clear water. By the end of July the water is clear of ice and snow for about a month or so but in September the surface freezes again. The shore and bottom are stony. The southern shore fringes the crest line. The lake has an outlet to the north and cataracts into the Chandra Valley. The lake is fed by melt water from the nearby peaks. During monsoon some rain water is also received. Vegetation on the shore is alpine in July and August. For greater part of the day the area is calm but in the mornings a fierce cold wind blows.

The route to the lake ascends to the left from the Rahla-Rohtang mule track near the Marhi Alpine meadow. After north-westerly ascent for about 4·0 kilometres, the crest of the range is reached and the lake comes into view. The lake is a place of pilgrimage for the people of Kulu, who visit it during the month of August.

Photograph I. Seragru Ice Fall below Gaphan-Schreckhorn Peak (5790 m. above mean sea level) in the Kulti Nal.

Seragru Ice-Fall 3800 m. (Photo. 1) TheIce Fall is situated in the Kulti Nal (Great Himalaya) about 5 kilometres from the river Chandra. It is in fact the snout of the Kulti Glacier. This glacier has its source in the Great Himalaya at about 5600 m altitude and runs in a westerly direction to a precipice of about 100-150 m before turning to a southerly course. From this precipice is the hanging column of ice or the Seragru Ice Fall. It is an enormous mass of snow, ice and glacial debris. The sculpturing of the mountain sides and the U-shape of the Kulti Nal provide ample evidences of the past extensive glaciation of the area (Fig. 4). The Kulti stream emerges from its bottom as a turbulent and turbid current and joins the river Chandra about 5 kilometres down to the south. The stream passes through almost a level glacial moraine in the beginning (Fig. 4) and then meanders through rocky abutments to take a turbulent course over stones and boulders before joining the river Chandra.

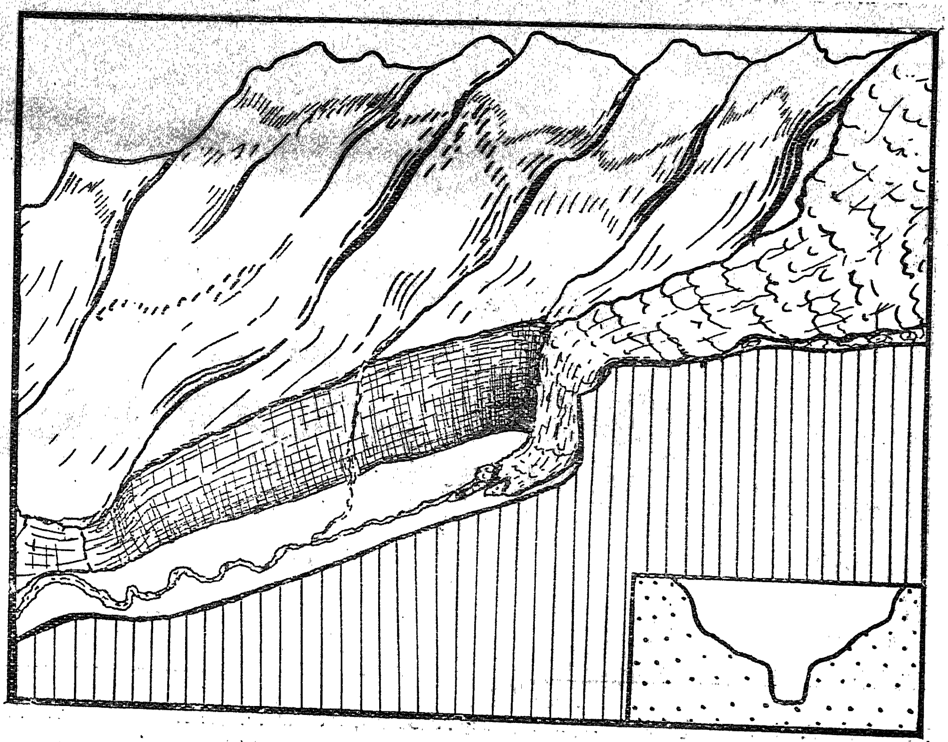


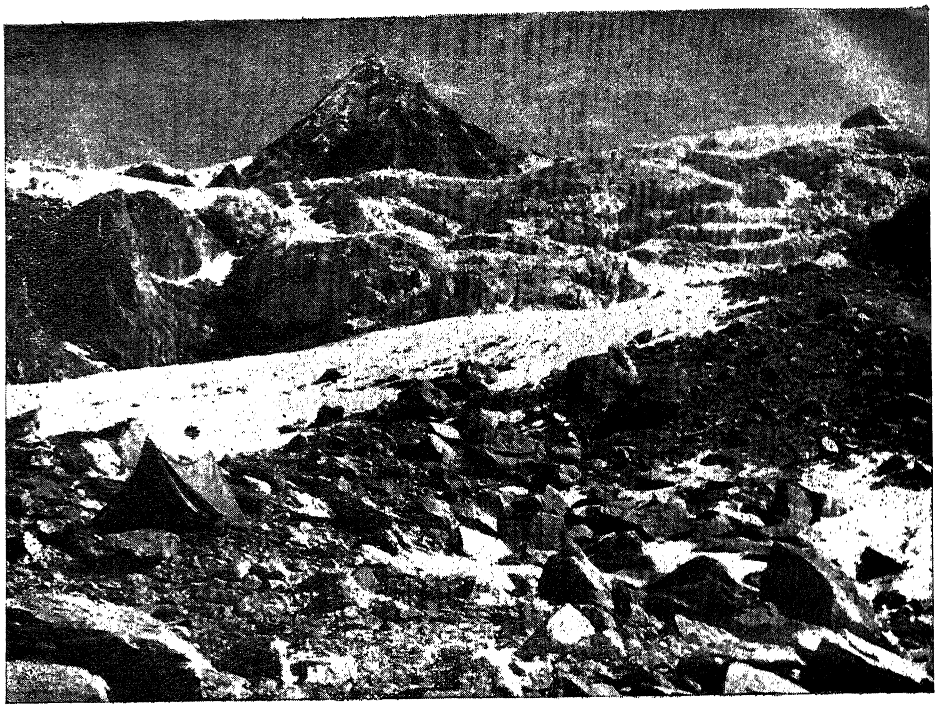
Fig. 4. A simplified diagram of the Kulti Nal, showing the Kulti Glacier in the U-shaped glacial moraine. Inset shows a cross section of the Kulti Nal with U-shaped valley.

Kulti is reached by crossing river Chandra at Khoksar about 10 kilometres from Rohtang Pass on a mule track along the right bank of the river. It is often possible to cross the river over the snow-bridges in early summer. The Kulti glacier and the Seragru Ice-Fall are visible from the summit of Rohtang Pass.

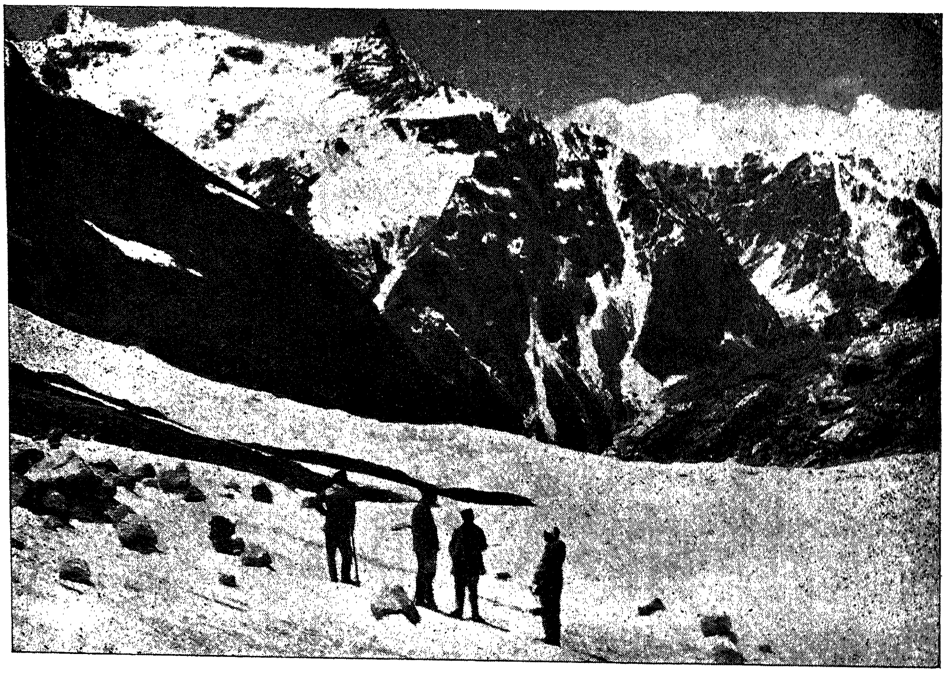
Sonapani Glacier (Seri Ice-Fall) 4550 m.—(Photo 2) This glacier is the source of the Purana Khoksar Nal stream in the great Himalaya of the Chandra Valley. The stream joins the river on its right bank at Chhatru about 6·5 kilometres down. The glacier is about 10 kilometres long. The north end is overlooked by a mighty wall of ice running east west. The snout of the glacier descends into the Purana Khoksar Nal gorge. After its emergence from under the snout of the glacier the Purana Khoksar Nal stream cataracts over stones and boulders through a narrow gorge to the river Chandra. Above the ice fall on the north of the glacier are numerous peaks reaching to 6000 m above mean sea level. The eastern and western edges of the glacier are covered with stones, boulders and debris brought down by avalanches. The eastern and western slopes of the Nal support only scanty growth of moss and lichen. Fierce and dry cold winds are not infrequent. Night temperature recorded was as low as -10·0°C. during the middle of June.

Photograph 2. Messrs Baijal and Kotpal on Sonapani Glacier, back after a climb. Seri Ice Fall behind, The unnamed peak in the background is 5860 m. high.

The route to the glacier from Chhatru lies on the right bank of the Purana Khoksar Nal for about 3-4 kilometres and then over mass of snow and boulders. Further up from this place the stream remains burried under snow for greatest part of the year. The glacier is reached after climbing another 3 kilometres by crossing the stream over numerous snow bridges from right to left and vice versa. In early summer the stream is frozen for most of its length and provides a comparatively easy way up to the glacier.



Photograph 3. Camp V on Sonapani Glacier, with avalanche debris in foreground and Seri Ice Fall behind. Snowfleas were active at night when air temperature was -10·0° C.



Photograph 4. On Sonapani Glacier snout, on way to Camp V and looking back south on the Pir Panjal in the background, across Chandra Valley.

Camp I

Alpine meadow on the southern slope of Pir Panjal Range, above Beas Valley about 0·8 kilometres to north of the Marhi P. W. D Gang Hut near the mule track to Rohtang Pass. A sheltered depression with shepherds' stone hut on its southern fringe. Traversed by a glacial torrent from north to south. Foot path from the mule track to the frozen Sarkund Lake along north-eastern edge. Overlooking the Marhi camping ground towards south. Eastern side with numerous boulders and stones. Ground with primulas and potentillas. Mornings and evenings often windy. Altitude 3648 metres.

Camp II

Gramphu Camping Ground on north slope of Pir Panjal Range in Lahaul, below and north of Rohtang Pass and about 8 kilometres from the Pass. Above left bank of river Chandra, about 5 kilometres east of Khoksar. Almost opposite of confluence of Kulti Nal with Chandra, and on the mule track to Spiti. Two glacial streams from Rohtang snows enter the river Chandra about 150 metres below and to the north. Alpine vegetation, exposed, windy. Altitude 3400 metres.

Camp III

A small alpine meadow on the right bank of Kulti Nal (Lahaul-Main Himalaya) about 2·5 kilometres from the confluence of the Nal stream with river Chandra. Small pool of stagnant water from melting snow to the west, overshadowed by a pricipitous ledge beyond the pool on the west. Kulti torrent on the east and about 15 metres below. About 40 metres to the north the Nal is spanned by a heavy snow bridge. A glacial stream to the north. With dwarf junipers and buttercups. Sheltered and calm. Altitude 3648 metres.

Camp IV

North-eastern corner of an extensive alpine meadow on the right bank of river Chandra in Lahaul-Main Himalaya, about 16 kilometres east of Camp II. Opposite Chhatru bridge. On the right bank of Purana Khoksar Nal, 1·6 kilometres from its confluence with river Chandra. A small spring to the south-west. About 1·6 kilometres to the north of Chhatru P. W. D Rest House. Occasional evening winds. Altitude 3496 metres.

Camp V

Sonapani Glacier (Photo 3), Seri Ice-Fall in the Main Himalaya about 6·5 kilometres up the Purana Khoksar Nal from its confluence with river Chandra. To the north a massive wall of ice, eastern and western sides loose stony slopes with frequent avalanches. The glacier snout into Puarana Khokiar Nal (Photo 4). Glacier strewn with stones and boulders brought down by the avalanches from eastern and western slopes. Barren and exposed. Windy. Altitude 4560 metres.

Camp VI

A small exposed area on the crest of the Pir Panjal Range on the southern shore of frozen Sarkund Lake (Dashair Lake) to the west of Beas Rikhi Peak and about 4 kilometres up and to the north-west of Camp I. To the south a deep gorge. To north the outlet of the Lake towards Chandra Valley side. Isolated patches of moss and lichen on small area uncovered by snow. Exposed and extremely windy. Altitude 4408 metres.

V. DESCRIPTIONS OF STATIONS

The total number of stations surveyed is 31, of which 17 are new and 14 refer to those where collections were made in previous years (Figs. 5, 6, 7 and 8). The stations include a variety of habitats like alpine meadows, barren rocks, snow-fields, glaciers, ice-falls, frozen lake, torrential streams, hot and sulphur springs. The descriptions of new stations serially numbered from 43 to 59 are given below and for earlier numbers refer to Mani and Santokh (*Loc. cit*). In the accompanying maps all the stations beginning from 1 to 59 are shown in circles. The station numbers are also given in the labels attached to the specimens.

List of Stations.

(43) About 100 metres length of glacial torrent in an alpine meadow about 40 metres west of Camp I; stony with algal slime. Altitude 3620 metres. Shielded partly from the Rohtang hurricane. Temperature of the water 3·5-4·5°C. The sides covered with primulas and potentillas in bloom.

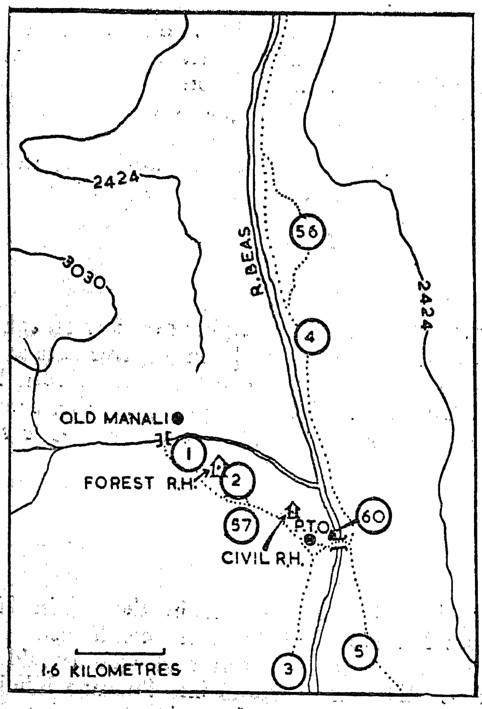


Fig. 5. Sketch map of Manali and adjoining areas. The numbers within circles refer to Stations. Chief contour lines are also shown.

(44) Barren rock on way to Sarkumd Lake, west of Beas Rikhi Peak (4600 m.) about 3 kilometres north and above Camp I. Covered by dry moss and lichen with loose stones. Atmospheric temperature 10·0°C. at noon Altitude about 4000 metres. Windy and exposed to the south with patches of snow.

(45) Sarkund Lake, frozen, altitude 4408 metres. West of Beas Rikhi Peak, 5 kilometres north of Camp I. With glaciers and snow fields on sides. Outlet to the north into the Chandra Valley. Bottom stony. Temperature of water 0°C. but in the outlet 0·5°C. Atmospheric temperature 4·0°C.

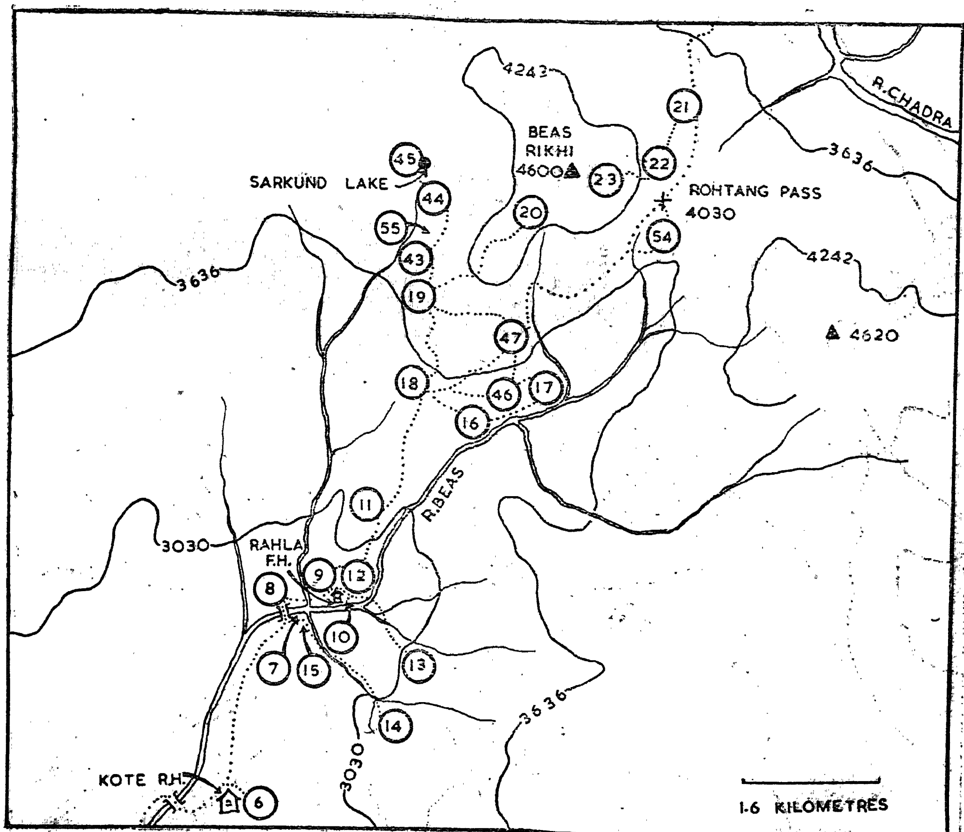


Fig. 6. Sketch map of the region near the source of River Beas, showing Rahla, Rohtang Pass, Beas Rikhi Peak and the Sarkund Lake. Numbers with in circles refer to Stations.

(46) Glacial stream on the slopes of the ridge west of river Beas, below and south of Rohtang, above stations 16 and 17, with pebbles and loose boulders covered by algal slime. Sides with moss and buttercups in bloom. Exposed. About 1·5 kilometres from Marhi P. W. D. hut.

(47) Eastern slope of the hill above mule track to Rohtang Pass, 1·5 kilometres north-east of Marhi P. W. D. hut, exposed, windy. Wild onion, iris and rubarb growing. Altitude 3742 metres.

(48) Slow flowing glacial stream, 3 kilometres up the Kulti Nal, joining the Nal on the right bank, passing through large boulders, sides with primulas, buttercups, moss and grass with snow patches nearby. Bottom with rounded stones covered with algal slime. Altitude 3660 metres. Water temperature 4·5°C.

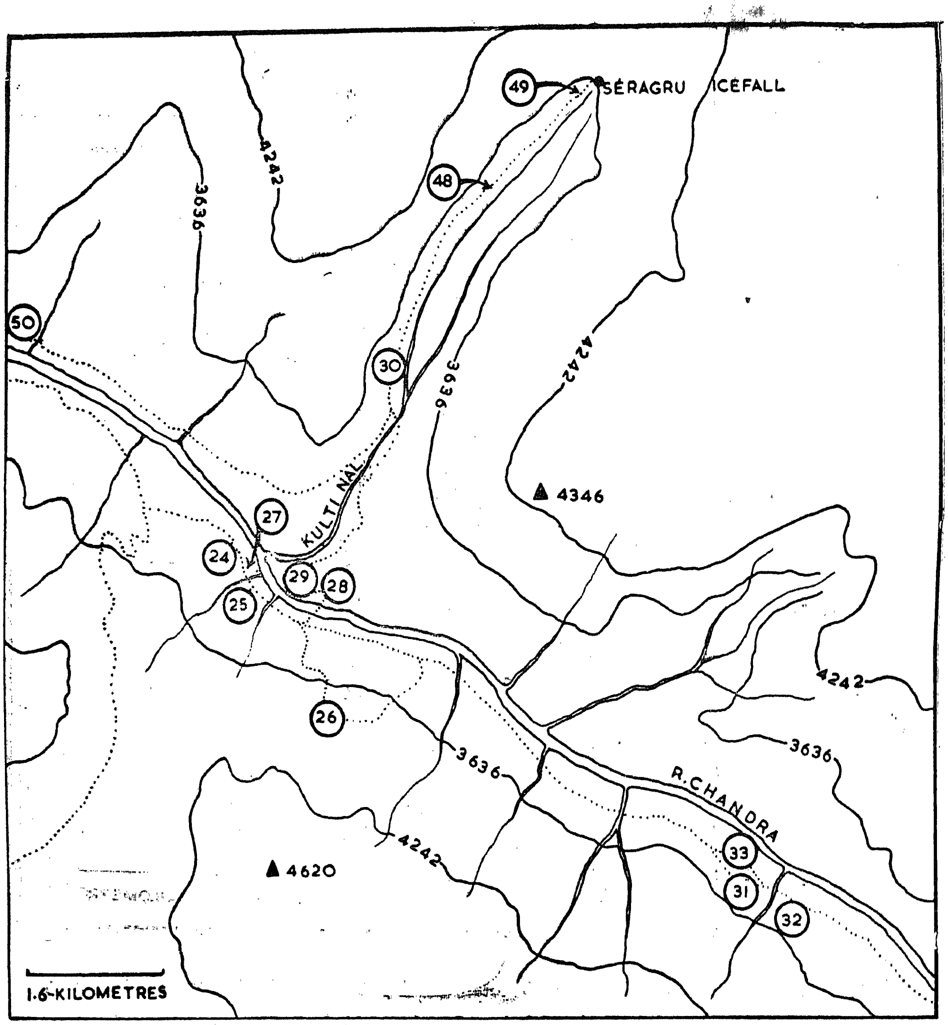


Fig. 7. Sketch map of the Kulti Nal area in the Chandra Valley, showing the Seragru Ice-Fall, with Stations in the circles.

(49) Foot of the Seragru Ice Fall in Kuiti Nal with ice and snow; water turbid with temperature of 0 5°C at 1·0 P. M. Sheltered. Altitude 3800 metres.

(50) Khoksar village, Kuth field, 1·5 kilometres from bridge over Chandra on the right bank. Altitude 3200 metres.

(51) Camping ground on north-east end of extensive alpine meadow about 1·5 kilometres to the north from river Chandra at Chhatru (refer station 39). Altitude 3400 metres. Buttercups and potentillas in bloom, with a small stream feeding the Purana Khoksar Nal.

(52) Meadow on the east of Purana Khoksar Nal, opposite station 51. Altitude 3400 metres. Exposed, warm, with wild carrot and potentilla growing.

(53) Glacial ice at base of Seri Ice Fall (Sonapani Glacier), 5 kilometres from river Chandra up the Purana Khoksar Nal. Littered with avalanch debris, exposed, windy. Altitude 4560 metres. Minimum temperature at night during mid June -10·0°C..

(54) Snow patch on the south end of the Rohtang Pass, just to the east of Beas Kund, 4030 metres above mean sea level. Facing Beas Valley and windy, exposed.

(55) Alpine meadow about 1 kilometre to the north of Camp I (Station 19) on way to Sarkund Lake, with a small torrent on the west. Primulas in bloom. Altitude 3880 metres.

(56) Paddy field north of Vasisht village about half a kilometre from the Manali-Kote mule track.

(57) Manali Forest Rest House grounds, about 2000 metres above mean sea level.

(58) Katrain, orchard opposite Civil Rest House, 1700 metres above mean sea level.

(59) Katrain. *Alnus nitida* plantation between river Beas and the Civil Rest House-a small stream running through the area, leaving stagnant puddles at places.

VI. FIELD WORK

In addition to the activities connected with the establishing of camps, the field work consisted mainly of collecting and preserving specimens of insects, and observations and recording of scientific data. A great deal of time was naturally spent in reaching supplies and opening up different camps in localities found suitable from previous experience. Careful planning beforehand and the resourcefulness of the members in face of unexpected conditions, greatly facilitated the work. Movements from one camp to another were generally restricted to early morning hours. Supplies from the base camp were carried partly by mules and partly by porters.

Collections of specimens were made mostly during the day. Specimens were collected from nearly every ecologic niche and from a fairly wide range of altitudes. While attention was mainly devoted to specimens above an altitude of 3000 m., many examples found somewhat below were also secured. The highest altitude at which a live and active insect was collected this year was about 4600 m. on the Great Himalayan Range. Wherever possible, large series of examples were collected in each case. The collections were sorted out, labelled and packed away each day in the field. A part of the evening programme comprised comparison of notes and discussions by the members at the end of a collection day.

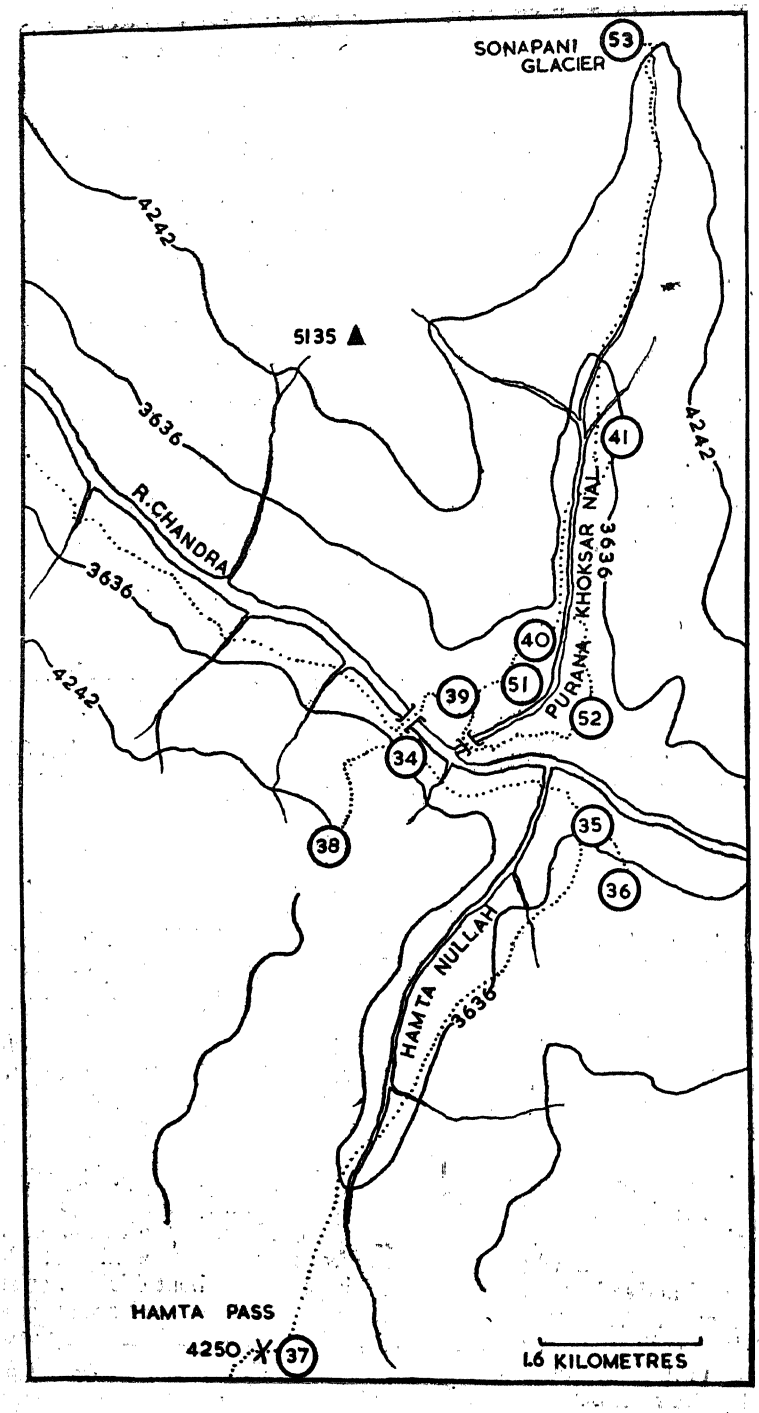


Fig. 8. Sketch map of Purana Khoksar Nal area showing the Sonapani Glacier, Hamta nullah and numbers in circles refer to Stations.

The total number of specimens brought back by the Expedition amounts roughly to 5000, the percentage systematic composition of which is shown in Table III (Fig. 9).

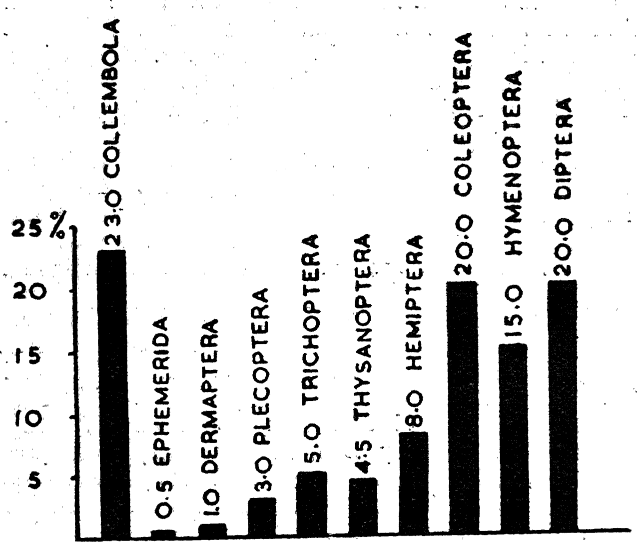


Fig. 9. The abundance of different orders of insects expressed as percentages out of the total collections.

TABLE III

Statement showing the systematic percentage composition of the total collections

No.	Orders	Percentage out of total collections
1.	Ephemerida	0·5
2.	Plecoptera	3·0
3.	Dermaptera	1·0
4.	Hemiptera	8·0
5.	Thysanoptera	4·5
6.	Coleoptera	20·0
7.	Hymenoptera	15·0
8.	Trichoptera	5·0
9.	Diptera	20·0
10.	Collembola	23·0

In comparison with the collections made in 1954 and 1955, the material this year should be considered poor in the number of species. Even localities which yielded a rich harvest of specimens in earlier years often proved nearly sterile. Insect activity during 1956 was on the whole slight and there was also an apparent decline in population levels of most species. This sparseness in the summer of 1956 is perhaps associated with differences in snow cover. The winter snow cover in 1956 was scanty and had also receded relatively early. Many species had completed the aerial stage in their life cycles and had already gone deep underground.

As in earlier years Collembola and Coleoptera are abundant as individuals in the material. There are many Hymenoptera this year. The proportion of larvae continues to be large and represent about one-third of the total collections. Ephemerida, Plecoptera, Blepharoceratidae, Simuliidae and Deuterophlebiidae are, for example, mostly larvae. Tipulidae were abundant though not as in earlier years.

Analysis of the catches on the basis of ecologic habitats shows (Table IV, Fig. 10) that the largest number of specimens were collected on snow fields, representing about 46·5 % of the total collection. About 22·0 % of the insects found on snow are true high altitude forms, but the rest represent wind-blown derelicts. Most of these derelicts were found dead and Collembola were feeding on their bodies. The wind-blown forms include many Diptera, especially Brachycera, Heteroptera, Homoptera (Aphididae), Lepidoptera, Plecoptera, Coleoptera and Hymenoptera (Chalcidoidea and Ichneumonidae). Amongst Diptera were large numbers of *Acanthiophilus helianthi* (Rossi) (Trypetidae). This fly is known to breed on *Carthamus* sp., at lower elevations as far away as Aut (on Mandi-Kulu road) about 105 kilometres to the south, at an elevation of 800 m. above mean sea level.

TABLE IV

Statement showing the ecological analysis of the total collections.

No.	Ecological catagory	Percentage out of total collection
1.	On snow	46·5
2.	Under stones	19·0
3.	On sheltered stones	10·0
4.	On vegetation	8·0
5.	In stagnatnt pools	7·5
6.	On flowers	5·5
7.	Light trap	3·5

Collections from under the stones and from stones sheltered by ledges were 19 % and 10 % respectively. From the vegetation mats of the alpine meadows, the collectios are 8·0 %; 7·5% comes from the stagnant pools mostly from below the timber-line, while 5·5 % were collected from Himalayan flowers like primulas,

buttercups and potentillas etc. Light trap collections represent only 3·5 % the lowest figure as on previous occasions.

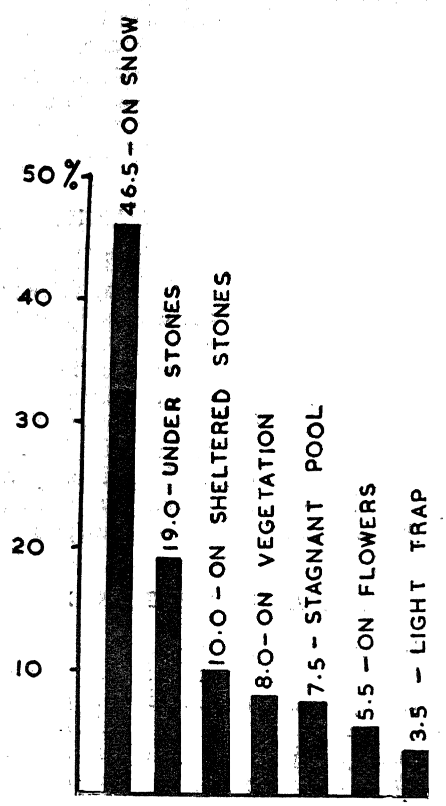


Fig. 10. Diagram showing the composition of the total collections on the basis of ecological niches expressed as percentages out of the total collections.

The wind blown insects on snow were usually mutilated as they were being devoured by swarms of Collembola. In some localities at an elevation of about 4408 m. on an average 5-10 specimens of Collembola were found per sq. cm. area of snow, and on certain patches imparted a sooty-black colour to the snow. Wind-blown derelicts were found only on the southern slopes, but wholly absent on the northern slopes. The Collembola, which were common on snow surface go under deeper layers of the snow after a storm and snow accompanied by a slight drizzle, and could only be obtained by scooping out the snow. An interesting behaviour of *Isotoma* sp. was observed at Sonapani Glacier 4580 m. (Sta. 53, photo 3). At about 7·0 P. M. there were no Collembola near our Camp but half an hour later the surface of the ice and snow was littered with these tiny insects and they were also observed jumping about inside the tent. Their activity continued right through the night but in the morning when the sun came up they were gone inside the crevasses in the glacier where the direct sun rays do not reach. Reference should also be made to another interesting collection. Larvae of *Nemoura* sp. (Plecoptera) were found under stones in a small frozen torrent at about an elevation of 4400 m. The temperature of the stream was about 0·5°C.

In addition to collecting specimens, observations on the special ecological conditions, habits and life cycles of the insects were continued. In the observations on high altitude insect ecology special emphasis was laid on the study of microclimatic factors, the great importance of which has already been stressed by Mani (1955). In addition to recording atmospheric temperature and humidity, a series of observations of temperature-humidity conditions in soil, on rock surface, in rock crevices, under stones, on and under snow, in water etc., were also made at different localities and altitudes.

VII. CONCLUDING REMARKS

While it is gratifying to note that, with very limited resources and after overcoming numerous, often serious difficulties, the Expedition was successful. Owing however to many unforseen circumstances it was not possible to complete the field programme as originally planned. We were also handicaped by want of trained porters, inadequate camping equipment and scientific instruments. The success of the Expedition was largely due to the credit of careful planning and organisation by Prof. Mani and to the willing co-operation and team-work of the members. The urgent need for a small field laboratory above an altitude of 3000 metres in Lahaul is felt more than ever. This laboratory would be in a position to make frequent sorties for collections and could be on the spot when unpredictable insect appearances synchronise with largely unknown and unexpected change of ecological conditions.

VIII. ACKNOWLEDGMENTS

I take this opportunity to offer my grateful thanks to Dr. M. S. Mani for guidance and keen interest in the work and giving me the opportunity to lead the Expedition. I am particularly grateful to various manufacturers of food products for their donations and courtesies to the Expedition. I must also thank Sardar Swaran Singh, D. F. O., Kulu, (Punjab) for facilities at Manali. I shall be failing in my duty if I do not thank my colleagues, the members of the Expedition for cheerfully offering their co-operation under extremely difficult conditions.

SOME NOTES ON THE WING VENATION OF *AULACOPHORA* (CHRYSOMELIDAE : COLEOPTERA)

By

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INTRODUCTION

The wing venation in Coleoptera has been described by a number of authors like Fowler (1912), Forbes (1922), Graham (1922) and others. In the family Chrysomelidae, the venation has been recently studied in *Chrysochus auratus* (Wilson, 1934), *Galerucella birmanica* (Khatib, 1946 and Varma 1956). This paper deals with the venation and folding of the wing in *Aulacophora.*

OBSERVATIONS

In *Aulacophora,* the main veins of the wings are the costa, subcosta, radius, radial sector, media, cubitus and anals (Fig. 1). The costa (C.) is situated along the anterior or costal margin of the wing and extends nearly upto its middle. The sub costa (Sc.) lies behind the costal vein and is much shorter than the costa. Distally, it joins the next vein, the radius (R_1). Normally the radius comes after the subcosta and almost immediately divides into R_1 and radial sector (Rs.). In *Aulacophora* the proximal portion of the radius sector is absent and thus the radius vein corresponds to R_1. After its union with the subcosta, it continues upto the middle of the wing. The radial sector is poorly developed and lies immediately behind R_1 vein; basally it is incomplete as its connection with the radius is absent. Near the middle of the wing after a small break it bends obliquely downwards and inwards and then again upwards to form a spur (rr) which is connected with R_1 by a small cross vein (r). Beyond this, it is again incomplete but further outwards in the folded apical portion of the wing its other branches can again be traced. These branches are represented by R_2, R_3 and smaller R_4 and R_5 veins. In *Aulacophora* the medial vein (M) is represented by its two branches, MA and MP. MA is degenerate and is faintly marked out only in the distal half of the wing. It is divided into two branches, M_1, and M_2, of which M_1 proceeds obliquely outwards and backwards and reaches the margin of the wing, but M_2 remains in the form of a short conical spur-like process which stops in the apical area. MA is connected by a very faint radio-medial cross vein (rm.) with the rr. or spur portion of the radius sector vein. A very faint cross vein m also connects MA and MP. MP is a strong vein in the middle of the wing and bends sharply down to meet the cubitus and is not divided into two branches M_3 and M_4 as in many insects. From the point of the union of MP and cubits, a single vein Cu Mp proceeds to the hinder border of the wing. Some authors like Forbes (1926) regard MP in those insects in which it is not divided into

M_3 and M_4 as equivalent to M_4 and there seems to be no doubt that at least the distal portion of MP corresponds to M_4 and thus the single vein CuMP has been labelled by the present author as CuM_4 following Forbes nomenclature. The cubitus (Cu) is a strong vein which at the base of the wing, is connected with the radius by a cross connection called the arculus. The cubitus runs obliquely downwards and outwards and as seen above, is connected with the M_4 (or MP.) branch of the media vein to form a single M_4Cu (or CU. MP.) vein. Out of the four anal veins, the proximal portion of the first anal vein is absent, so that only its distal part 1 A is seen. The second anal vein 2 A starts from the articular membrane and runs obliquely backwards and outwards towards the posterior margin of the wing. Near its middle, it is joined on its anterior side by the first anal vein, the bent connecting portion actually representing a cross vein a, which was originally present between 1 A and 2 A The third anal vein 3 A runs behind the 2 A and joins the latter at the level where a joins 2 A. The fourth anaf vein (4 A) is a small vein which runs backwards and stops short of the posterior margin of the wing.

Due to the fact that during rest, the second wing is folded beneath the elytra, a number of folds are developed in it (Fig.2). In the present account the system of Forbes (1926) has been followed in demarcating the areas which are reversed during folding and the upright areas. These areas have been clearly marked out in Fig. 2 and require no detailed description. The areas which are reversed during folding, have been dotted in the figure and are represented by the following areas: (i) Axillary (J.) ; (ii) Antimedian (C.) ; (iii) Pivot (D.) ; (iv) Principal (H.) ; (v) First costal apical (E) ; (vi) Median (A) ; (vii) First anal (G.) ; (viii) Proximal pivot (B.). The upright areas are left unshaded in the figure and are represented by the following areas : (i) First Dorso-apical (X) ; (ii) Stigmatal (R) ; (iii) Central (S) ; (iv) Oblong (W) ; (v) First costal (P) ; (vi) Outer anal (V) ; (vii) Wedge (T) ; (viii) Cubital (U) ; (ix) Second central (Q).

GENERAL REMARKS

The wing venation in *Aulacophora* belongs to the Cantharid or Telephorid type according to the classification adopted by Ganglbauer (1892) and others. Fowler (1912), in Fauna of British India, has mentioned that in members of this type, there is great veriation and the type as a whole undergoes so much modification and sometimes breaks down so entirely that its value becomes very doubtful. The characteristic median loop, formed at some distance from the apex of the wing by the coalescence of the two median veins, one of which is continued to the margin from the centre of the top, is entirely absent in *Aulacophora.* The loop which is typically formed at the apex of the radial veins, is however, present and is formed between the radius and the radial sector veins by rr. (Fig. 1). In typical forms, transverse veins join the cubitus and anal veins but in *Aulacophora* such connections are absent. Thus, the wing venation in *Aulacophora* is a highly modified variation of the cantharid type.

The wing venation of *Aulacophora* closely resembles that of *G. birmanica,* but there are some important differances. In *Aulacophora,* the subcosta retains its individuality from the very base, but in *G. birmanica* the base of the costa and subcosta are fused proximally for a comparatively long distance. The radial sector is a comparatively well developed, though slender vein, and only a very small portion of it towards the base is absent, but in *G. birmanica,* it is very much reduced proximally and is represented only by a small spur distally. In *Aulacophora,* the radial recurrent, though it approaches R_1 closely, remains unconnected with the latter, but in *G. birmanica,* however, the radial recurrent is united with R_1. Distally the radial recurrent (rr.) is connected by a cross vein r. with the distal end of R_1 in both the cases. The media is similar in both *Aulacophora* and *G. birmanica.*

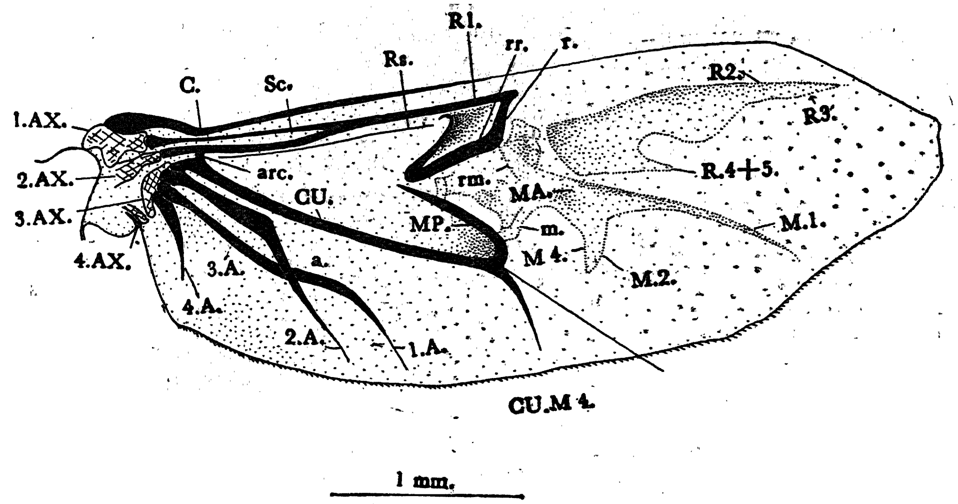

Fig. 1. *Aulacophora foveicollis* Luc. The metathoracic wing of the right side illustrating the wing venation, and the disposition of the axillaries.

1A.--4.A.—1st Anal to 4th Anal veins; a.—cross vein between 1st Anal and 2nd Anal veins; arc.—arculus; 1.AX.—4.AX—Axillary sclerites from 1st to 4th C.—costa vein; CU.—Cubitus vein; CU. M.4.—common stem of cubitus and media (CU. MP.); M.—media; M.1.—M.4.—branches of media from 1 to 4; MA.—anterior branch of media; m.—cross vein between MA. and MP.; m. cu.—cross vein between media and cubitus; R.—radius vein; R. 1 to R. 5—Distal branches of radius vein; r.—radial cross vein; rm.—radio medial cross vein; rr.—Spur of radial sector; Rs.—radial sector vein: Sc.—Sub-costa vein.

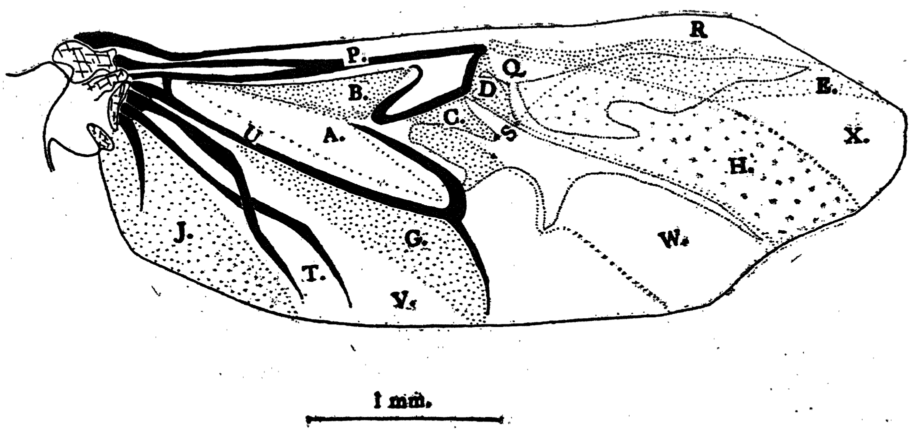

Fig. 2. *Aulacophora foveicollis* Luc. Metathoracic wing of the right side, showing folding pattern. The areas which are reversed during folding, have been dotted in the figure and are represented by the following areas—(J.) Axillary; (C.) Antimedian; (D.) Pivot (H.) Principal; (E.) First costal apical; (A.) Median; (G.) First anal; (B.) Proximal pivot.

The upright areas are left unshaded in the figure and are represented by the following areas:—

(X.) First dorsoiapical; (R.) Stigmatal; (S.) Central; (W.) Oblong; (P.) First costal; (V.) Outer anal; (T.) Wedge; (U.) Cubital; (Q.) Second central.

The hypothetical main stem of the media is absent in all Coleoptera and is represented by two veins, an anterior MA. and a posterior MP. In *Aulacophora* as well as *G. birmanica,* MA. is degenerate and lies in the distal folded portion of the wing only, where it divides into two branches M_1 and M_2, of which M_1 goes upto the margin of the wing, but M_2 stops in the apical area. In *Aulacophora,* M_1 is without any spur like process as is found in *G. birmanica.* MP is similar in both the cases and is in the form of a prominent vein in the middle of the wing which bends sharply downwards to join the cubitus. From the point of union of these two veins, in both *Aulacophora* and *G. birmanica,* a single vein proceeds to the hinder border of the wing which may be regarded as Cu + MP. (M_4 + Cu of Forbes, because MP also normally divides into two, M_3 and M_4, and in these animals at least the distal part of MP corresponds to M_4) In both *Aulacophora* and *G. birmanica,* there is a very faint radio medial cross vein rm. between Rs and MA., and a very faint medial cross vein m. between MA and MP; a distinct arculus, connecting the cubitus and radius near their bases, is also present in both the cases.

As regards the anal veins, the cubito-anal cross vein cua., which connects 1A with cubitus in *G. birmanica,* is absent in *Aulacophora,* and thus the proximal portion 'a' of 1A in *Aulacophora* corresponds to the cross vein CV, which connects 1A and the common portion of 2A and 3A. In other respects the anal veins in the two cases are similar.

SUMMARY

The wing venation belongs to a highly modified cantharid or telephorid type. The characteristic median loop formed at some distance from the apex of the wing by the fusion of the two median veins, is absent; the loop at the apex of the radial veins is present and is formed between radius and radial sector veins and by rr.; transverse veins joining cubitus and anal veins are absent; the proximal portion of the first anal vein is also absent.

ACKNOWLEDGMENT

The author has great pleasure to express his indebtedness and sincere gratitude to Professor D. S. Srivastava, for his kind and valuable guidance.

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THANATOSIS RESPONSE OF BEETLES TO PYRETHRUM AND NICOTINE POISONING

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As thanatosis (or death-feigning) of insects is a nervous response connected with the ganglia and nerves (Saverin & Severin 1911, Kozanshikov 1931, Robertson 1904, and Holmes 1906), chemical stimulants which act on the nervous system may also affect thanatosis. With this view thanatosis response was utilized to study the action of pyrethrum and nicotine on the nervous system of some common species of Coleoptera.

MATERIAL AND METHOD

An equal volume of absolute alcohol was added to commercial 20% pyrethrum extract and left for several hours to precipitate resinous substances. The solution was then filtered and the resin-free 20% pyrethrum was diluted with analar petroleum ether (b. p. 100-120) and liquid paraffin mixed in the ratio of 4:1, to make 5% a stock solution. The required concentrations were then prepared from the 5% stock solution, which was kept in the dark in a refrigerator. It was made certain that the solvent alone does not produce any effect by a number of preliminary experiments. 1% stock solution of nicotine was prepared by diluting 95% commercially pure nicotine with the diluent used for pyrethrum solution.

Calandra granaria L. and *Calandra oryzae* L. were reared in glass jars on wheat grains at a constant tamperature of 25°C ± 1°C. *Coccinella septempunctata* and *Adalia bipunctata* collected from the field were reared in the laboratory as well as in the open. A number of coccinelids were left on a branch infested with aphids and protected by muslin. When a considerable number of eggs had been laid, the parents were transfered to another branch, as it was noticed that some coccinellids ate their own eggs. The parents as well as the larvae were supplied with fresh aphids from time to time. The newly emerged insects were kept in a cage with aphids at room temperature and were allowed to mature for about 10 days, when they were ready for experiments.

Attempts were made to rear the coccinellids in laboratory, Coccinellids were kept in large beakers closed by muslin covers and containing branches of green plants infested with aphids. After a considerable number of eggs had been laid the parents were transfered to another beaker, and the eggs were allowed to hatch. The aphid infected branch was changed every third or fourth day and the rearing was carried out at a temperature of 24°C ± 1°C.

The following technique was used to apply the insecticides and to assess their toxic effect ;

Whatman filterpapers 7 cm. in diameter were impregnated with 0·5 ml. of the insecticide solution, providing a thin film of the insecticide on which the test insects, whilst confined within the metal rings were allowed to crawl for the desired period of treatment. A thin coat of paraffin was given on the walls of the rings, in order to prevent the insects from climbing the walls, and thus ensuring their contact with the poison for the entire period of treatment. The period of thanatosis was recorded according to the method already described by the author (Saxena 1957).

EXPERIMENTS WITH PYRETHRUM

After conducting preliminary experiments to find out the range of sublethal doses of pyrethrum for each species, the insects, were subjected to the following treatments.

Out of 13 batches each of 20 *C. granaria*, 9 were treated with 0·04%, 0·06%, 0·08%, 0·087%, 0·093%, 0·1%, 0·2%, 0·4%, and 0·8% pyrethrum and the remaining 4 treated with solvent were run as control. The treatment was given for 24 hours, (Table I.) In case of *C. oryzae* a treatment of 0·05%, 0·08%, 0·09%, 0·1%, 0·3%, 0·5%, 1·0% and 1·5%, pyrethrum to 8 batches, each of 20 insects, was given 3 batches were run as control. The insects were exposed for 4 hours to insecticide, (Table I.) Out of 70 insects, 50 were exposed to 0·02 , 0·05%, 0·08 , 0·1% and 0·2%, pyrethrum for 24 hours in the case of *C. septempunctata* and for 3 hours in the case of *Adalia bipunctata*. The remaining 20 were subjected to solvent only (Table 1).

The duration of thanatosis in each of the above experiments was determined after an incubation period of 24 hours except in *A bipunctata* where 12 hours were allowed. The mean transformed duration of thanatosis was plotted as ordinate against the concentration spaced logarithmically as abscissae (Figs 1,2,3 & 4).

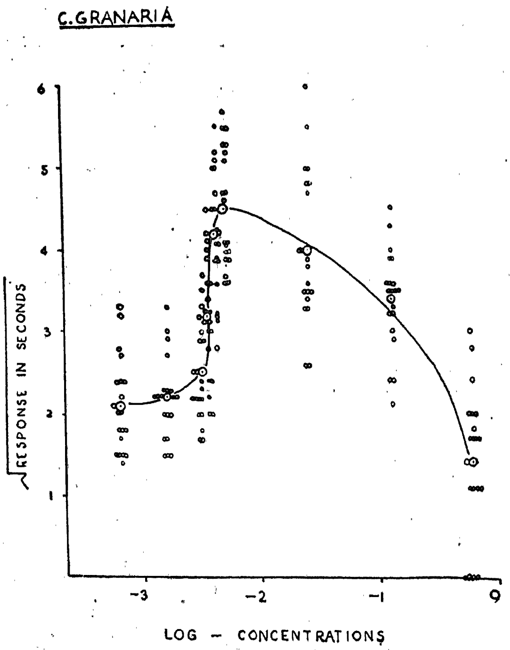

Fig. 1. Thanatosis response of the insects treate with pyrethrum.

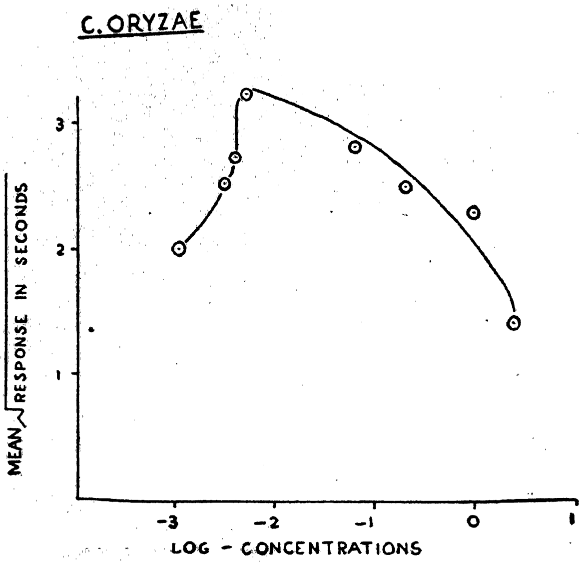

Fig. 2. Thnatosis response of insects treated with pyrethrum.

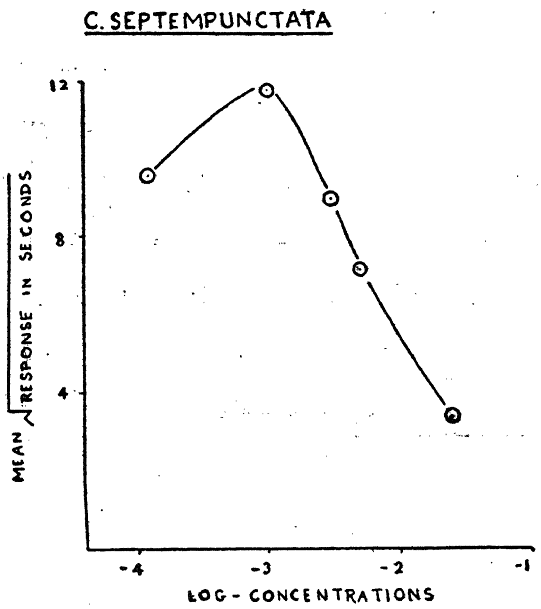

Fig. 3. Thanatosis response of Coccinellids treateh with pyrethrum.

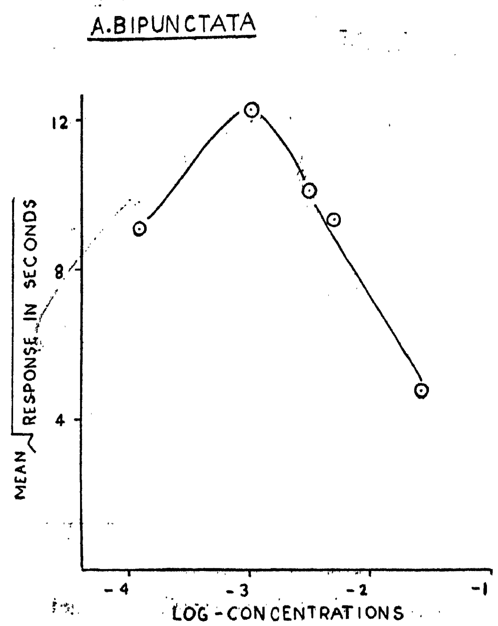

Fig. 4. Thanatosis response of Coccinellids-treated with pyrethrum.

TABLE 1

Thanatosis response of beetles to pyrethrum poisoning.

	Mean values of 20 insects												
	Response in seconds to different pyrethrum concentrations												
	04%	·06%	08%	·087%	·093%	0·1%	0·2%	0·4%	0·8%	CONTROLS			
Calandra granaria	2·1	2·2	2·5	3·2	4·2	4·5	4·0	3·4	1·4	2·7	2·3	2·2	2·1
	0 05%	·08%	·09%	0·1%	0·3%	0·5%	1·0%	1·5%	CONTROLS				
Calandra oryzæ	2·0	2·5	2·7	3·2	2·8	2·5	2·3	1·4	2·1	2·3	2·0		
	·02%	·05%	·08%	0 1%	0·2%	CONTROLS							
	Mean values of 10 insects												
Coccinella septem-punct-ta.	9·58	11·8	8·9	6·98	3·37	9·15	9·55						
	·02%	·05%	·08%	0·1%	0·2%	CONTROLS							
Adalia bipunct. ta	9·1	12·2	10·0	9·3	4·7	8·2	7·8						

EXPERIMENTS WITH NICOTINE

Two different experiments with C. *granaria* and C. *oryzae* were performed for studying the action of nicotine on the weevils. In one experiment the rerponse observed was the duration of thanatosis and in the other 'Knockdown', a stage of paralysis.

Experiment No. 1

Duration of Thanatosis as a Respouse—Out of nine batches each of 20 C. *granaria*, six were treated with nicotine at concentrations of 0·01%, 0·03%, 0·05%, 0·08%, 0·1%, and 0·3% and three with solvent, for a period of 1½ hours. In case of C. *oryzae* the treatments of 0·01%, 0·03%, 0·05%, 0·1% and 0·3% were given to 5 batches, each of 20 insects, and 3 batches were run as control. The exposure was given for 1 hour.

The duration of thanatosis in both cases was recorded after an incubation period of 24 hours. (Table II).

Experiment No. 2

Knockdown as a Response—450 granary weevils and 375 rice weevils were taken at random for the experiment and were subjected for the treatment with the same concentrations as in experiment no. 1. There were 2 replicates each of 25 insects, for each concentration. After exposure the insects before counting were stimulated by the warm plate method (Tattersfield and Potter 1945), in which the plate, on which the beetles were placed, was kept warm at 38°C—40°C, by placing a 25 Watt bulb, about 4 inches below it for about 2 minutes, (Table II.)

The mean transformed periods of thanatosis recorded in experiment no. 1 and the percentage of the insects paralysed calculated in experiment no. 2, were plotted as ordinates against the concentrations spaced logarithmically as abscissae (Figs. 5 & 6).

TABLE II

Thanatosis and knockdown response of beetles to nicotine poisoning.

		Nicotine concentrations					
	Response ...	·01%	·03%	·05%	·08%	0·1%	0·3%
Coladra granaria	Knockdown percentage.	0	8	37·3	90·6	97·3	100
	Mean duration of thanatosis in seconds.	6·0	5·2	5·6	5·3	5·7	5·9
	Controls		5·2	5·1	5·6		5·5
		·01%	·03%	·05%	0·1%	0·3%	
Calandra cryzae	Knockdown percentage.	1·3	34·6	72·0	97·3	100	
	Mean duration of thanatosis in seconds.	5·8	6·0	6·1	5·1	5·6	
	Controls	4·8		4·9		5·6	

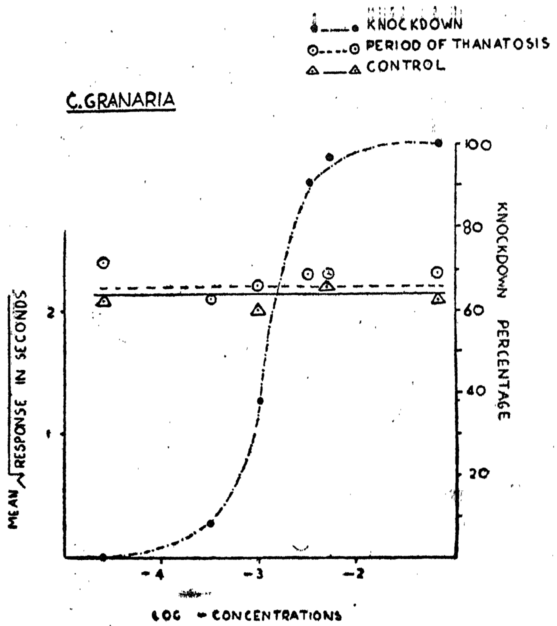

Fig. 5. Thanatosis and Knockown responses of the insects treated with nicotine.

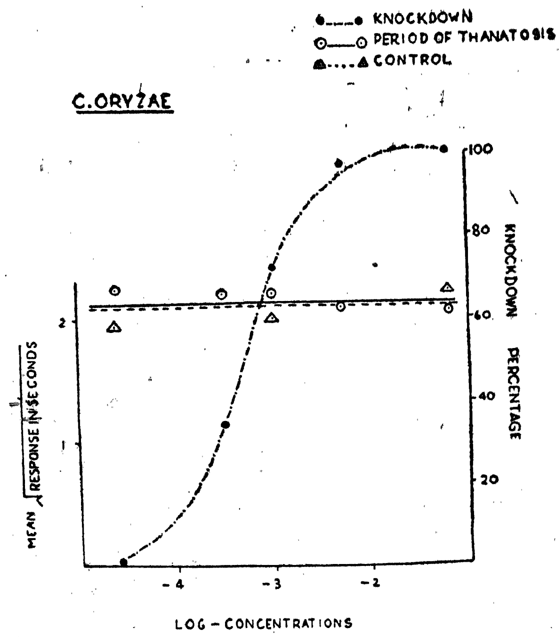

Fig. 6. Thanatosis and Knock down responses of the insects to nicotine.

RESULTS

From the above mentioned experiments it is observed that no change in the duration of thanatosis takes place upto a certain concentration of the insecticides concerned. On increasing the concentration the duration of thanatosis increases upto a certain concentration. At a still higher concentration the period of thanatosis decreases till the insect dies. (Table III, Figs. 1-6).

TABLE III

Insects	A	B	C
Calandra granaria ...	0·06 (24 hours)	Approx. 0·1% (24 hours)	0·1% (24 hours)
Calandra coryzae ...	Approx. 0·05% (4 hours)	Approx. 0·1% (4 hours)	0·1% (4 hours)
Coccinella septempunctata.	Approx. 0·02% (24 hours)	Approx. 0·05% (24 hours)	0·05% (24 hours)
Adalia bipunctata ...	Approx 0·02% (3 hours)	Approx. 0·05% (3 hours)	0·05% (3 hours)

A—No change in the duration of thanatosis was recorded on treating the specimens upto the following concentrations noted against each insect for the period of treatment mentioned in brackets.

B—The duration thanatosis increases on treating the insects beyond he concentrations mentioned in the column 'A' upto the following concentrations given for the period noted in brackets.

C—On treating with the concentrations beyond the following, noted against each insect the duration of thanatosis decreases till the insect dies.

C. granaria treated with concentrations lower than 0·2% pyrethrum, showed normal behaviour and no external symptoms were noticed. Tremor of legs was clearly observed among the affected insects. 0·4% pyrethrum treated *C. granaria* were not in a condition to walk straight and majority of insects, who were found standing quietly on their legs, when were made to walk, did so for a short distance and then fell over their backs, feebly waving their legs in the air. They appeared to be feeling and responding the stimulus and were feeding the grains. Insects treated with a higher concentration 0·8% pyrethrum were unable to walk, lying motionless on the filter papers and were not able to respond to the stimulus in the normal way. When the stimulus was applied, they tried to run away instead of feigning death. Some of the insects remained stationary and could not even feel the stimulus.

Similar observations were made with *C. oryzae* and coccinellids on treating with higher concentrations of pyrethrum.

The succession of symptoms induced by pyrethrum in *C. granaria* and *C. oryzae* may be summarised as follows :—

1. Normal movement is maintained although the duration of thanatosis rises slightly and there is a tendeney to become excited.

2. Excited stage in which movement is abnormally rapid. The duration of thanatosis decreases.

3. Progressive paralysis, movements are slower and irregular, locomotion is erratic.

4. Complete paralysis with almost no movement unless force is used to stimulate the insects to move. Insects in this stage soon die. The mean value of the duration of thanatosis falls to a very low value, less than one second.

There was no change in the duration of thanatosis of the weevils of either species when treated with n'cotine. It is clear however that the treatment had a marked effect on the insects as shown by experiment no. 2, there was a graded knockdown respone covering the range 0·8% to 100% of the insects. Clearly the nicotine absorbed has not all been metabolised.

No tremor of legs was noticed in insects poisoned with nicotine. Affected insects were found lying motionless and as they were touched they fell over on to their backs. Unlike the insects treated with pyrethrum, the weevils were not found walking inco-ordinately, or lying on their backs with their legs waving in the air. Also the weevils which were completely paralysed and appeared to be dead, completely recovered when left for a time in the fresh air. There was a quick knockdown and a quick recovery of insects treated with nicotine and a slow recovery of insects treated with pyrethrum.

DISCUSSION

Treatment of insects with different sublethal doses of pyrethrum results in three changes in the duration of thanatosis. (*i*) The period of thanatosis is unaffected upto a certain concentration; (*ii*) the treatment beyond this threshold concentration results in the increase in the duration of thanatosis; (*iii*) on further increasing the concentrations the duration of thanatosis begins to decrease until a stage is reached when the insects, instead of feigning death, responds by running away on the application of the stimulus. The insects treated with still higher concentrations fail to respond to the stimulus and eventually die.

The treatment with low concentrations of pyrethrum apparenty results in absorption of the insecticides slowly enough for its concentration at the site of action to be kept down by metabolisation to a harmless level at which no change in the duration of thanatosis and perhaps in the transmission of impulses by nerves, is produced.

Treatment at somewhat higher concentrations results in an accumulation of insecticide and the initiation of a series of nervous impulses. Roeder and Weint (1946, 1948) believe that repetitive trains of impulses may be produced in sensory nerves by exposure of the sense cells of the companiform organs to DDT at concentrations as low as 0·01 p. p. m. If an insect has been treated with an insecticide at this level of concentration its nervous system is, in a way, sensitised, so that when nerve impulses which induce thanatosis are generated in it by the application of mechanical stimuli, these impulses are superimposed on those produced by the insecticide and their effect in maintaining thanatosis is augmented.

Treatment at still higher concentrations results in such an increase in the frequency or amplitude of the impulses transmitted that the relevant centres become overstimulated and exhibit a fatigue similat to that induced by repeatedly applying mechanical stimuli to normal insects. At this stage the duration of thanatosis is reduced and at the upper threshold of concentration, thanatosis is not induced at all.

The effect of nicotine on the insects appears to be quite different from that of pyrethrum. The experimental results show that no change in the duration of thanatosis was exhibited by the insects treated with different concentrations of nicotine. In order to obtain evidence that these concentrations had not been metabolised by the insects and did infact have considerable effect on them, another treatment with the same concentrations was given and the knockdown response was taken. Hence it appears that nicotine does not affect the sensory nervous system and the author agrees with Roeder (1953) that nicotine appears to have little or no action on impulse conduction along axons. Likewise, Wilcoxon and Hartzell (1933) detected no histological changes in the nerve ganglia of insects killed by nicotine sulphate. Considering other symptoms, it was found that those exhibited after nicotine treatment were quite different from those shown by the insects treated with pyrethrum. Symptoms such as tremor of legs, inco-ordinate locomotion and the insects lying on their backs with their legs waving in the air, were not shown by the insects subjected to nicotine.

SUMMARY

It is believed that pyrethrum affects the sensory nervous system of the beetles (*C. granaria, C. oryzae, C. septempnctata, A, bipunctata*), and produces trains of impulses, thus promoting the thanatosis response at certain concentrations. It appears that higher concentrations produce a state similar to 'fatigue' when the insects fail to show the thanatosis response. Nicotine does not seem to affect the nervous system in this way.

ACKNOWLEDGMENT

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ROOT COMPETITION AND TRANSPIRATION STUDIES ON SAL SEEDLINGS

By

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Introduction

The management of *Shorea robusta* forests is being seriously effected by the lack of established reproduction in most of the important sal tract of Uttar Pradesh, specially in the submontane and tarai divisions like Haldwani, Ramnagar, Bahraich etc. In these divisions there are standing crops of good quality sal but the regeneration dies out repeatedly or dies back and does not establish. This failure of regeneration has been studied by several workers such as Hole (1914), Champion (1933), Warren (1940) and Giriffith and Gupta (1947) and Puri (1954). They attributed many causes for the failure of regeneration of sal, one of them is that the availability and utilization of water by sal seedlings during the critical growth period is the limiting factor. The general survival is also regulated by adequacy of soil moisture all the year round. Water logging caused during rains and drought during summer are equally inimical. These earlier investigations therefore suggest a quantitative study of water intake, transpiration and moisture competation in the floristic complex containing the sal seedlings throughout the year. Accordingly a study on transpiration and root competition with regard to sal seedlings and important associated weed species was carried out in the Demonstration area of the Forest Research Institute during November 1956 to November 1957.

Method of layout of the experiments

Transpiration studies on sal seedlings were carried out in weeded and unweeded plots maintained for the root competition experiments. Along with the transpiration rate for *Mallotus philippensis* and *Clerodendrum infortunatum* were also recorded for one year from January 1957 to Nov., 1957. Calcium chloride was used for absorption of water transpired from both the surfaces of the leaf of these seedlings. Two plastic funnels (equal areas were used, two funnels for each) into which small rods of calcium chloride were used. The whole system was made air tight. The experiment was conducted for five hours a day. Record of temperature, humidity rainfall and water contents of soil from 0-50 cms depts were also kept for purposes of corelation with transperation.

For the assessment of root competition of sal seedlings with other ground floor vegetation Six plots were maintained each measuring 40 ft by 10 ft Each of the plots was divided into two parts of 20 × 10 ft one of them being trenched allround (trench 4ft deep and 2 ft wide) to sever the roots of tree species growing near these plots thereby eliminating the competition of bigger trees with seedlings of sal. These

trenched and untrenched plots were again sub divided into equal halves of 10×10 ft, one sub plot being weeded and the other unweeded. The trench was refilled and again dug up and refilled after six month's interval in order to cut those roots which grew into the experimental plots during the interval. In each of these four sub plots some seedlings were marked and their growth in height was measured after every one month up to one year from November 1956 to November 1957.

Results

As it is very clear from the graph the rate of transpiration of sal (*Shorea robusta*) seedlings in the weeded plots is the heighest, the lowest rate of transpiration being for *Clerodendrum infortunatum.* The curve for *Mallotus philippensis* shows that the rate of transpiration is slightly lower to that of sal seedlings in the weeded plots but only at few points it goes higher than the sal seedling. Rate of transpiration for sal seedling in unweeded plots is lower than both for sal seedlings in the weeded plots and *Mallotus philippensis* but greater than that for *Clerodendrum infortunatum.* The rate of transpiration is high during March to June for all species, the heighest value being recorded in the month of May, with the onset of rains the curve for all species goes down considerably from June to August. Later on it rises again. There is a negative corelation between humidity and the rate of transpiration. Humidity being high during June, July and August the transpiration rate is low and humidity being low during March, April and May, the transpiration rate is high.

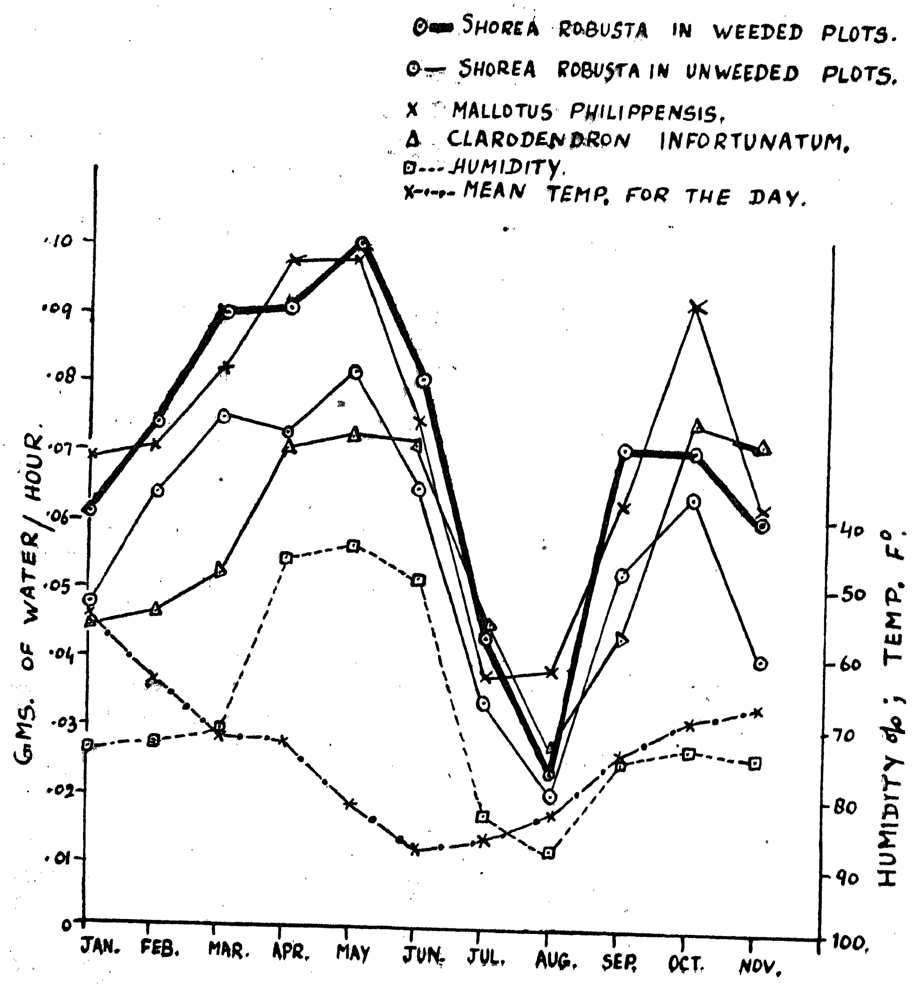
In the root competition studies the best growth in height is shown by sal seedlings growing in the weeded and trenched plots, growth of the seedlings growing in the unweeded trenched plots is comparatively poorer than the weeded plots. For the untrenched plots similar results were obtained, growth being good in weeded plots. But there is not a marked difference between the growth of trenched weeded and untrenched weeded, though comparatively trenched plots show better results. For all seedlings the best growth is shown from March to June. Seedlings from the weeded plots show considerably good growth from the first growth season i. e. from March onwards than those from the unweeded plots, In the beginning of the experiment till the first growth season there seems to be not much effect of weeding.

Discussion

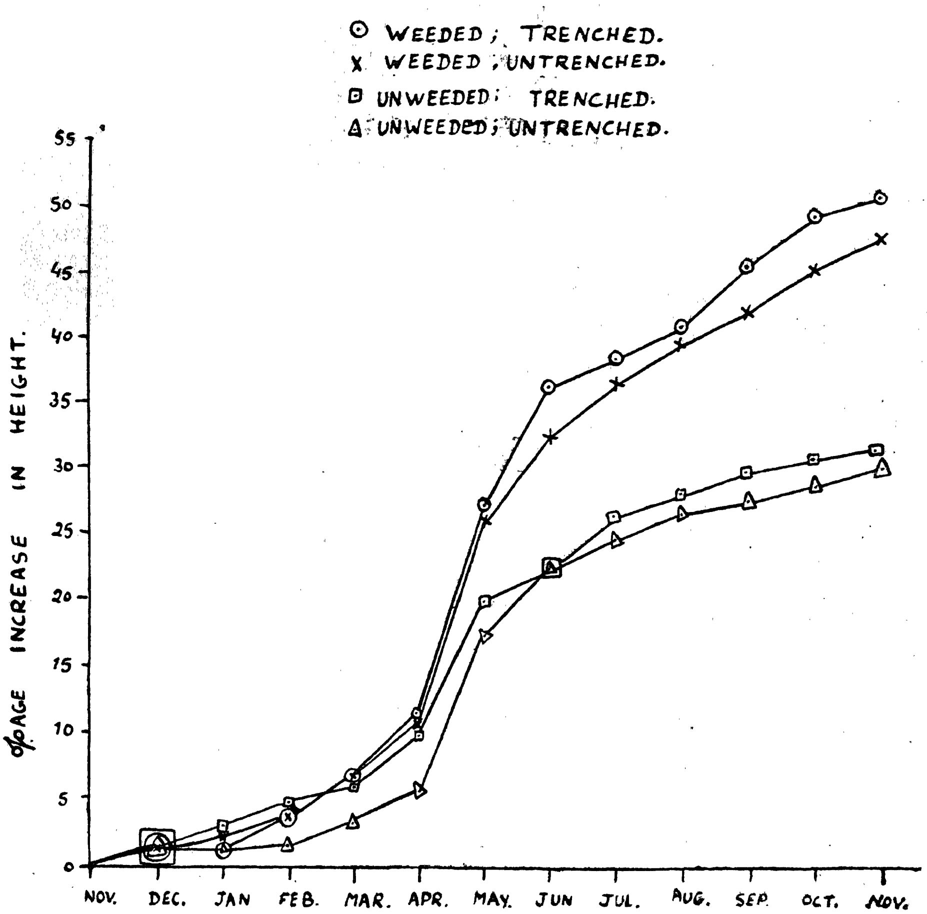
Since sal seedlings transpire more in the weeded plots than the unweeded, we can assume that sal seedlings require more water for transpiration than what they get in natural forest conditions. This difference in the availability of water between weeded and unweeded plots probably be due to competition of other species for the available moisture, it is also evident that weeds do exert a substaincial inhibiting influence on the growth of sal seedlings. The studies show that *Mallotus philippensis* is probably the chief competitior for soil water, its rate of transpiration being comparable to that of sal seedlings in the weeded plots. *Clerodendrum infortunatum* on the other hand show low rate of transpiration than sal seedlings in unweeded and weeded plots, therefore probably it may not be a acute competitor for soil water in the natural forest conditions.

In root competition experiment the plots which were weeded show better growth in both trenched and untrenched conditions. Therefore it is evident that due to competition the weed do exert substancial inhibitihg influence, on the growth of sal seedlings, correspondingly the rate of height growth is faster in the weeded plots. As regards the influence in trenched and untrenched plots according to graph there are two distinct groups. In both the cases of weeded and unweeded conditions the growth in height is comparatively better in trenched portion, therefore it is

TRANSPIRATION.



Root Competition.



obvious that trenching also induce better growth, though the difference in growthis not much. This small difference probably be due to the deep root system of tree species there by there may not be acute competition between sal seedlings and tree species. The best growth in height is shown by seedlings of weeded and trenched plots.

As the water is of paramount importance in the physiology of plant because it dissolve all minerals contained in the soil and transport them to the plant, it maintains turgidity without which cell cannot function actively, therefore any factor influencing water uptake will result in poorer growth and probably this competition of water may be one of the cause for poor growth of sal seedlings in unweeded plots.

Suggestions

The course of water from the soil upward through the plant is of minor importance if viewed from ecologic point of view, but its intake and loss is of great concern, because these processes of intake and loss are conditioned by environment, therefore fruitful results can be reached at if we try to solve the regeneration problem of sal by eeological and physiological researches together.

Thus a complete study of soil moisture, i e. Permeability, Water content, Moisture equivalant, Maximum retentive capacity Hygroscopic coeffecient, Wilting coeffecient etc. should be conducted of good and bad regeneration areas with the study of environment. This may throw a great deal of light on the acute problem of natural regeneration of *Shorea robusta.* Priliminary studies on these lines have already been started at the Ecology laboratory of the forest Research Institute Dehra Dun.

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AN EXPERIMENTAL STUDY OF THANATOSIS IN *CHILOMENES SEXMACULATA* FABRE

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INTRODUCTION

Thanatosis (or death-feigning) has been studied in the past by several entomologists like Holmes (1903, 1906 1907 and 1908) in terristrial amphipods and *Ranatra*; Robertson (1904) in spiders; Severin and Severin (1911) in *Belostoma flumineum* and *Nepa apiculata*; Audova (1928) in *Geotropes stercorarius*; Reisinger (1928) in *Dixippus morosus*; Weyrauch (1929) in *Forficula*, Kozanshikov (1931) in *Lochmaea capreaea*; Hase (1933) in Triatoma, Godgluck (1935) in *Neides*; Weiss (1944, 1947 and 1951) in *Bruchus obtechus*; *Aloba'es Pennsylvanica, Alobates barbata, Idiobates castaneos, Boletotherus bifurcus* and *Diplotaxus liberta*; Teyrovsky (1949) in *Gyrinus natator*; and Saxena (in press) in *Calandra granaria, Calandra oryzae, Cocccinella septempunctata, Adalia bipunctata Carausius morosus* and *Armadillidium vulgare.* Most of these authors, have described the posture of the animal during thanatosis and the induction and termination of thanatosis but only few have touched upon the factors affecting this phenomenon. The present paper is an experimental study of death feigning in the coccinellid *Chilomenes sexmaculata* Fabre.

MATERIAL AND METHOD

Specimens of *Chilomenes exmaculata* were collected from *Calatropis procera* (Hindi-*Madar*) plants found in the grounds of the Zoology Department, University of Saugar, during the months of October, November and December 1957, and reared in the laboratory. For the purpose of rearing, the insects were kept in large muslin-topped beakers, each containing a green branch of *Calatropis peocera* infested with aphids. After a considerable number of eggs had been laid the parents were transferred to another beaker, as it was noticed that some of the insects ate their own eggs. The adults, larvae as well as newly emerged imago kept in separate beakers and were supplied with fresh aphids from time to time.

Prehandling of an insects shortly before stimulating it to feign death induces a state of excitement which may prevent its responding to the stimulus. Hence it was thought necessary to allow experimental insects to remain undisturbed for a reasonable time before recording the duration of thanatosis. With this view, these coccinellids provided with aphids were confined, individually, within the muslintopped funnels standing on filter papers, for a number of hours before they were used in an experiment. For recording the period of death feigning the funnel was lifted and thanatosis was induced by applying mechanical stimulus. In all experiments the termination time was recorded on the movement of antennae.

While studying the effect of light it was found necessary to prevent the heat of the bulb reaching the experimental insects and therefore for this purpose the apparatus and the method employed by the author were as described in an earlier paper (Saxena, 1957). The experimental insects prior to subjection to light were conditioned separately, for 24 hours in dark, and were supplied with aphids during this period.

The following objects arranged in order of hardness were used as source of the mechanical stimulii :—

1. **Air.**—A hollow glass tube for blowing air on the body of the insects.
2. **Cotton.**—A little cotton tightly wrapped at the end of a poined glass rod.
3. **Thread.**—A piece of stiff thread tightened to the free end of a glass rod.
4. **Brush.**—A 'O' number camel hair brush with a tapered end.
5. **Finger.**—Pressure applied by the index finger.

All the experiments were performed with the adults of nearly the same age, at a temperature of 24°C. In order to make the distribution of data approximately even so as to make the variance in any group of observations independent of the mean, the duration of thanatosis was transformed by the square root method and the transformed values were plotted on the graph.

OBSERVATIONS

I. A General study of Thanatosis.

(a) *Induction of thanatosis* :—

In these insects the best method of evoking thanatosis is by mechanical stimulation. Another method is to drop the insect from a height of a few inches. If a branch on which the beetles are walking is jarred, the fallen insects, sometimes, show thanatosis. Induction of thanatosis is also possible by a slight pressure exercised for a while on the dorsal or ventral surface of the body but it is not induced by blowing air over its body from a glass tube. In the present series of experiments, thanatosis was induced by lightly pressing the ventral side of the insects by means of the index finger.

(b) *Posture in thanatosis* :—

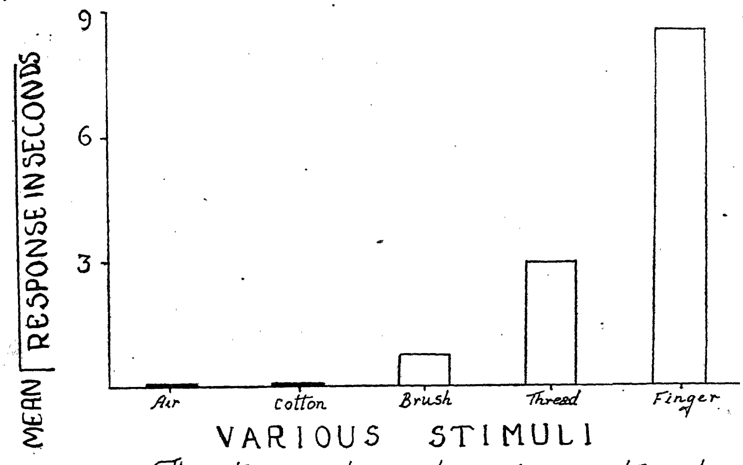
During thanatosis, the coccinellids cease all movements, tightly press their legs to the body and remain immobile for sometime; the head usually moves down touching the fore-legs with the antennae pressed to the head. All the legs contract in such a way that the femora, tibia, and tarsi become folded on one another. The only movement commonly observed during thanatosis is a slight and intermittent trembling of the tarsi of the first pair of legs.

(c) *Termination of thanatosis* :—

The termination of thanatosis is usually indicated by a slow movement of the head. In *C. sexmaculata* termination begins with the unbending of the antennae, along with the erection or upward movement of the head followed by frequent jerky movement of fore-legs and then of the remaining pairs of legs.

(d) *Thanatosis is response to various stimuli* :—

50 coccinellids taken from a collection were divided into 5 equal batches and were subjected to Air, Cotton, Brush, Thread and Finger stimulii, showing the periods of thanatosis of 0, 0, 2·5, 15·52 and 73·46 seconds respectively (Fig. 1). These results show that there is a relation between the length of the period of thanatosis and the intensity of the stimulus. The possibility of such a correlation was pointed out by Weiss in 1947.



1 Thanatosis response to various stimuli

(e) *Effect of repeated application af the stimulus on thanatosis* :—

The insects become unresponsive to the stimulus on subjecting them to a series of repeated applications of the stimulus. The coccinellids collected from the field were allowed to lead a normal life for 24 hours in the funnels before they were subjected to a series of stimulus. Each successive stimulus was applied on the termination of thanatosis induced by the previous stimulus. A fall from 84·76 seconds to 0 second was recorded at the 7th application of the stimulus (Fig. 2).

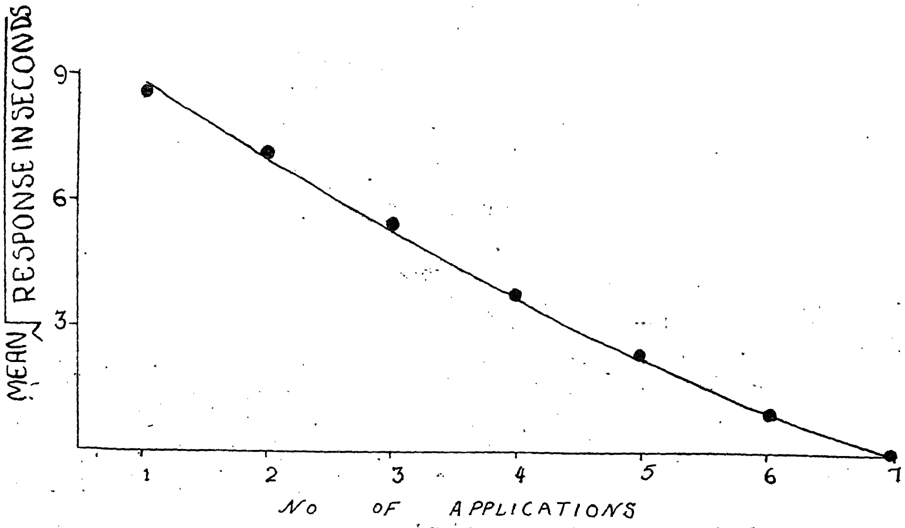


Fig. 2. Thanatosis response to Continuous application of the stimu'us.

The period of thanatosis decreases gradually with the increase in the number of repeated applications of the same stimulus, and finally the insects become so much excited that ultimately they cannot be induced thanatosis. These observations are in accordance with those of Kozanshikov (1931). The failure of the insects to show thanatosis may be due to the fatigue stage reached by the insects after a number of applications.

(f) *Thanatosis at different ages*:

The period of thanatosis in newly emerged beetles is shorter than in the matured ones. 10 newly emerged coccinellids were tested on the day of their emergence and the duration of thanatosis was recorded. After this the insects were left individually under the funnels and the durations of thanatosis were recorded daily till 10th day of emergence. The insects were supplied with aphids during the entire experimental period. The insects showed a duration of 3·2 seconds on the day of emergency and acquired the normal duration of 80·2 second after about 10 days of emengence. It has also been observed that complete pigmentation among these insects takes nearly the same period as the attainement of the normal duration of thanatosis (Fig. 3).

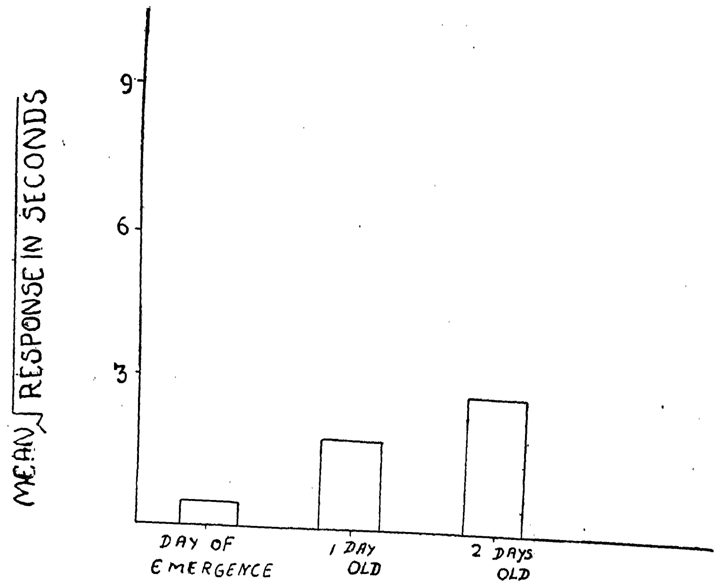


Fig. 3. Thanatosis at different ages.

II. Effects of physical factors on thanatosis

(a) *Effect of stavation* :—

10 insects collected from the field were divided into two batches. Batch A was kept starved and the batch B was fed with aphids. The period of thanatosis of Batch A was recorded after 6, 12 and 18 hours of starvation and of the batch B after similar intervals of feeding. The results show that there is an increase in the period of thanatosis from 101·12 seconds to 272·2 seconds

after 18 hours of starvation (Fig. 4), showing that starvation causes an increase in the duration of thanatosis.

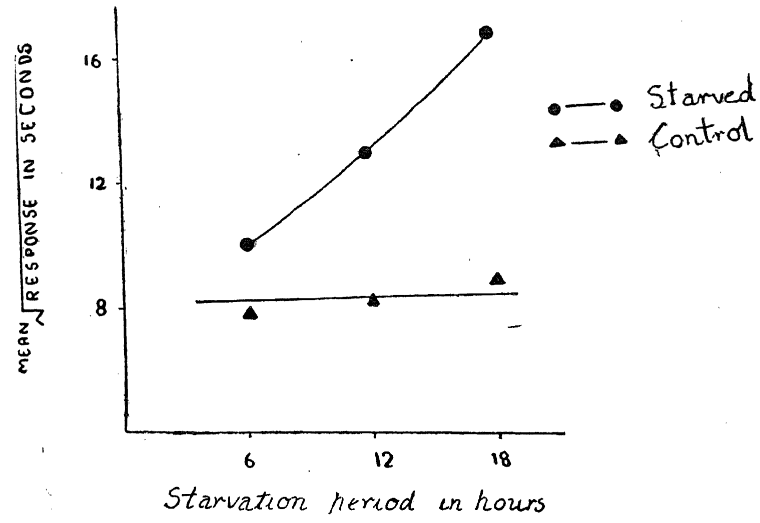


Fig. 4. Thanatosis response to Starvation.

(b) *Effect of illumination:—*

(*i*) Response to different illuminations :

3 batches, each of 10 coccinellids were exposed to 3 different illuminations provided by bulbs of 220, 160 and 100 watts. and the periods of thanatosis were recorded, which show that the duration of 67·4 seconds under 100 Watts. is reduced to 16·20 seconds under 220 Watts. (Fig. 5). These results, which were also obtained

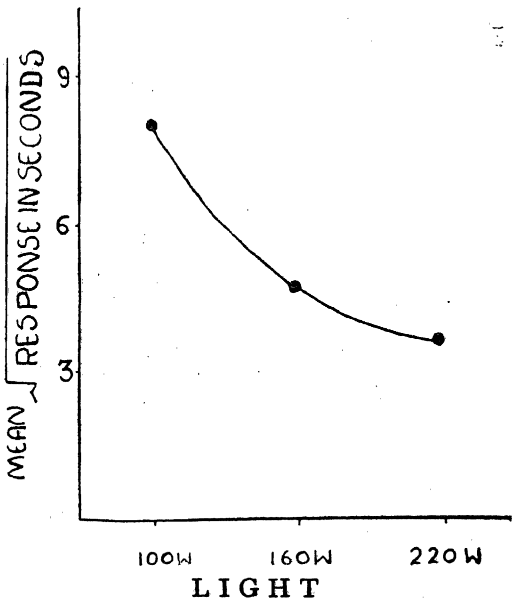


Fig. 5. Thanatosis response to different light illuminations.

by Holmes (1906) while working on *Ranatra*, show that the duration of thanatosis is inversely proportional to the light intensity. The fall in the period of thanatosis may be due to the excitement caused by the light stimulation.

(*ii*) Response to increased period of exposure to light :

The different periods of exposures of the same illumination affects the thanatosis response, in the same way as that of different illuminations at fixed period of exposure. 30 insects divided into 3 batches of 10 each were exposed under 100 Watts. bulb for 1, 2 & 3 hours; the duratoin of thanatosis was 47·72 seconds after I hour exposure and 23·84 seconds and 14·52 seconds after 2 and 3 hours exposures respectively, (Fig. 6). These results show that the duration of thanatois decreases with the increase in the period of irradiation by light. At long exposures the insects were found in excited condition.

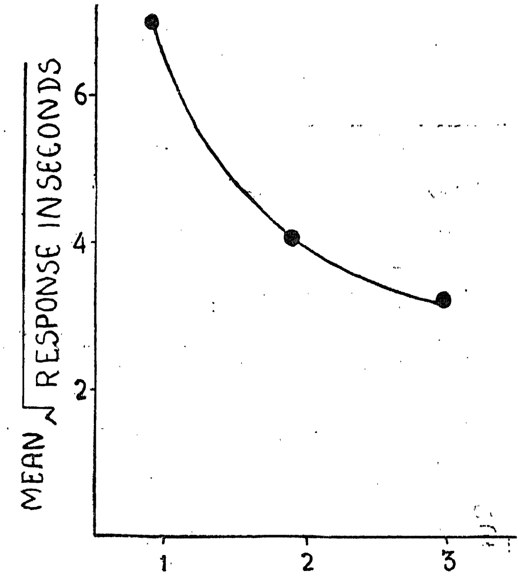


Fig. 6. Thanatosis response to different periods of exposures.

(c) *Effect of temperature* :—

The periods of thanatosis of 196·6, 144·0 and 62·72 seconds of 3 batches, each of 10 coccinellids were recorded at the temperatures of 12°C, 17°C and 27°C. These results indicate a decrease in the duration of thanatosis with an increase in temperature (Fig. 7). Holmes (1906) also obtained the similar results with *Ranatra*.

(d) *Effect of heat radiations* :—

20 insects were divided into two batches A and B of 10 insects each. Batch A was run as control and the period of thanatosis was determined under normal conditions. Insects of batch B were individually subjected to the heat radiations just after the induction of thanatosis and the durations of thanatosis were determined. A hot dissection needle was used for transmitting the heat radiations to the insects. The needle was heated in a flame for 30 seconds and was brought about ½ cm. away from the right antennae of the insects which were lying down in the state of thanatosis. The results show that there is a reduction in the period of thanatosis after subjecting the insects to heat radiations (Fig. 8).

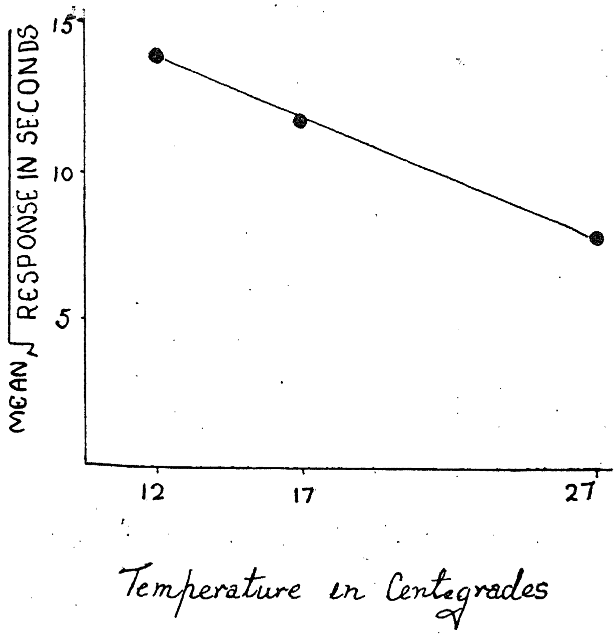


Fig. 7. Thanatosis at different temperatures.

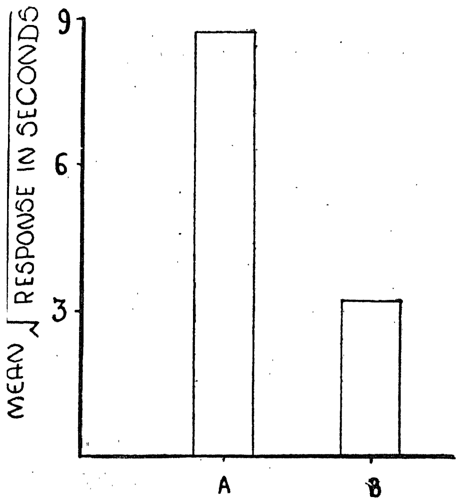


Fig. 8. Effect of radiant heat on the response of Coccinellids.

SUMMARY

In *C. sexmaculata* thanatosis may be induced by applying a hard stimulus like finger. The coccinellids assume an immobile posture by tightly pressing their legs and antennae to the body. The termination of thanatosis is sudden and begins with a slow movement of antennae followed by a movement of first pair of legs.

Different periods of thanatosis are recorded on applying the various stimuli varying in the degree of hardness. The harder the stimulus the greater is the duration of thanatosis.

After repeated application of an stimulus, a fatigue stage is reached when the coccinellids cease to respond to stimulus.

Newly emerged beetles show shorter duration of thanatosis which reaches the normal period about 10 days after emergence.

Starved insects show longer duration of thanatosis.

Insects exposed to brighter illumination or for a longer period to the same illumination, show a decrease in the duration of thanatosis.

The duration of thanatosis decreases with increase in temperature.

The duration of thanatosis is also reduced on subjecting the insects to heat radiations.

ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks to Prof. D. S. Srivastava for his constructive criticism during the investigation and for providing the facilities which enabled me to carry out this work in the Department of Zoology, University of Saugar. I am also grateful to Dr. A. S. Srivastava Entomologist to the Govt. U. P. and Officer-in-charge Plant Protection, Uttar Pradesh for kindly identifying the beetle.

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SOME AQUATIC FUNGI OF ALLAHABAD
A TAXONOMIC STUDY

By

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Introduction.

In the course of his investigation on aquatic fungi, the author became interested in a group of water moulds belonging to order Saprolegniales although, this group has received a greater attention of the mycologists as compared to others. Most of these water moulds have been recorded from foreign countries specially Europe and America. The record from India in this respect is rather poor. Among the Indian workers mention may be made of Butler (1907, 1911), Chaudhuri (1935, 1936), Bhargava (1945) Das Gupta et al (1953) and (Miss) John (1955).

A number of forms have been collected and are now under examination. A few of them are described in this paper. Of the species described two have been reported occurring new in this country. A new variety of *Achlya-aplanes* is also reported. Others have been described as they are new from Uttar Pradesh and differed in some respects from older descriptions.

Material and methods.

Majority of these water moulds reproduce by means of zoospores. Water containing these zoospores was collected from various ponds of Allahabad. It was then poured in large Petridishes. Various baits such as freshly boiled house fly, hemp seeds, corns, twigs, leaves etc. were placed in the Petridishes. They were then taken out after about 24 hours and were washed by distilled water. Finally they were placed in dishes containing distilled water and in a day or two, infection appeared on them. Pure cultures of these organisms were made according to the technique described by Couch (1939).

Description of the species

Saprolegnia parasitica Coker.

Plant delicate, hyphae straight, slender, little branched, the larger threads having a diameter of about 36 μ on hemp seeds halves, average being about 18 μ, sporangia plentiful, club shaped, about 30 to 36 μ in diameter, furnished with a short papilla, secondary sporangia formed generally by the proliferation through the empty ones and also by cymose branching, spores diplanetic, formed in several rows as in *Achlya*, varying in behaviour, some swimming away while others becoming sluggish. No sexual organs developed in the plant even inspite of various efforts. The following media were tried.

1. Agar Agar.
2. Solution of Leucin (·1%) with tri-calcium phosphate (·1%).
3. ·01% haemoglobin.

4. Laevulose and Leucin (M/200).

5. ·1% Kno_3.

6. ·1% $KH_2 PO_4$

7. ·1% Na_2HPO_4

8. On hard boiled egg yolk.

9. On sterlised dead fishes.

10. Equal parts of ·05% haemoglobin and ·25% NaH_2PO_4 on house fly.

11. On corn meal agar.

12. ·05% haemoglobin and ·2% potassium phosphate.

13. ·05% haemoglobin and ·2% potassium nitrate.

14. ·05% haemoglobin and ·1% potassium phosphate and ·1% potassium sulphate.

15. ·05% haemoglobin and ·1% potassium phosphate and ·1% sodium chloride.

16. ·05% haemoglobin and ·1% sodium-hydrogen-phosphate and ·1% potassium sulphate.

17. ·05% Leucin.

18. ·05% Leucin and ·1% potassium phosphate.

19. ·05% Leucin and ·1% calcium phosphate.

20. On boiled corn grain pieces.

21. Peptone ·025% and leucin ·025%.

22. Peptone ·025% and maltose ·025%.

Cultures were maintained at about 25°C in an incubator.

This species has been reported first from Lahore by Chaudhuri but complete description was not given. Now it has been described from U.P. also. An effort was made to induce sex organs, but was of no avail. Sex organs were only described by Kanouse (1932) in his culture.

Isoachlya unispora Coker and Couch.

Mycelium vigorous on hemp seeds halves, hyphae irregular, not straight, little branched, about 9 to 36 μ, sporangia few primary ones elongated, 360 μ long and 36 μ wide, proliferation very common and internal, spores diplanetic, 9 to 11 μ at rest, emptying as in *Saprolegnia* and swimming sluggishly, some coming quickly to rest. Gemmae plentiful, oogonia occassionally seen in the culture, embedded in a mass of hyphae, mostly spherical diameter 18-39·6 μ, mostly 30 μ thick, wall clourless, smooth, generally without pits. Eggs usually one or two rarely three, or four, 14·6—39·6 μ thick, mostly 25·2 μ, eggs centric, antheridia never developed.

Isoachlya toruloides Kauffman & Coker.

Mycelium delicate but vigorous on hemp seeds halves, moderately branched, about 9-36 μ, sporangia cylindrical, proliferating internally, abundant in culture.

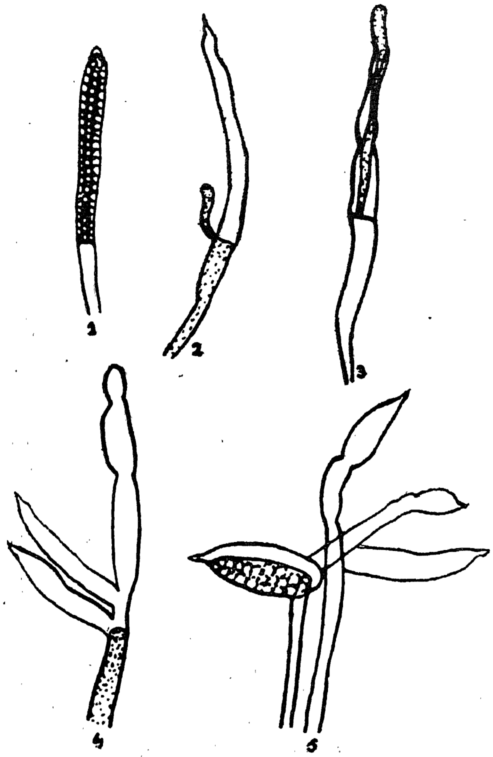

Plate 1. **Saprolegnia parasitica**

Fig. 1. A mature sporangium ×100

„ 2. A sporangium showing lateral proliferation ×100.

„ 3. A sporangium showing internal proliferation ×100.

„ 4. A group of sporangia of normal appearance ×100.

„ 5. A group of sporangia produced as in Achlya ×100.

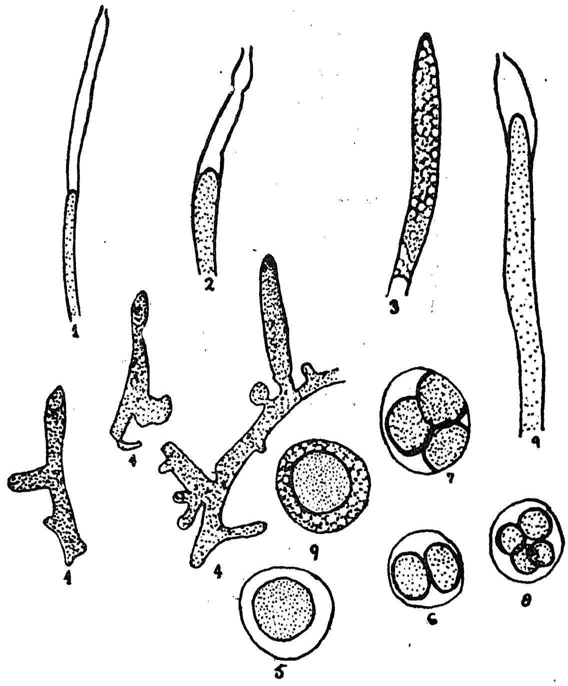

Plate 2. **Isoachlya unispora**

Figs. 1 & 2. Showing empty sporangia ×100.

„ 3. A mature sporangium ×100.

„ 4. Gemmae ×100.

„ 5, 6, 7 & 8. Oogonium containing 1, 2, 3 & 4 eggs ×400.

„ 9. Structure of the ripe egg ×400.

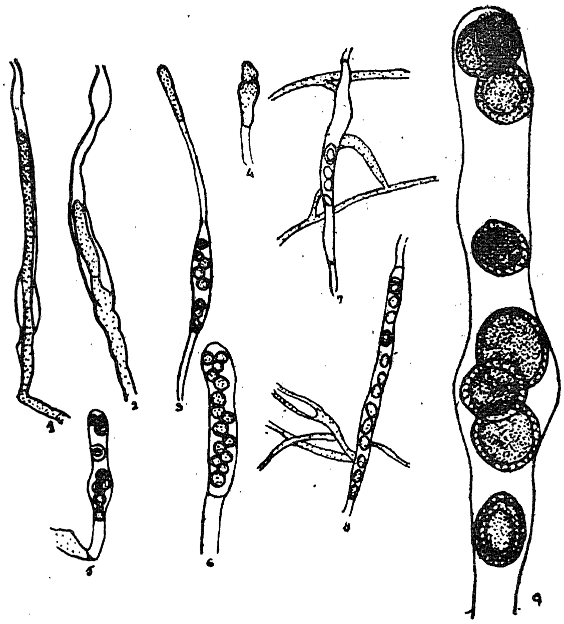

Plate 3. **Isoachlya toruloides.**

Fig. 1.	Proliferation through an old sporangium ×100.
„ 2.	Sporangium showing internal proliferation ×100.
„ 3.	Sporangium and an Oogonium on same hypha. ×100.
„ 4.	Gemmae ×100.
„ 5. & 6.	Oogonia containing eggs without antheridia ×100.
„ 7.	Oogonium containing eggs with antheridia. ×100.
„ 8.	Oogonia with ripe eggs ×100.
„ 9.	Oogonium containing eight mature eggs ×400.

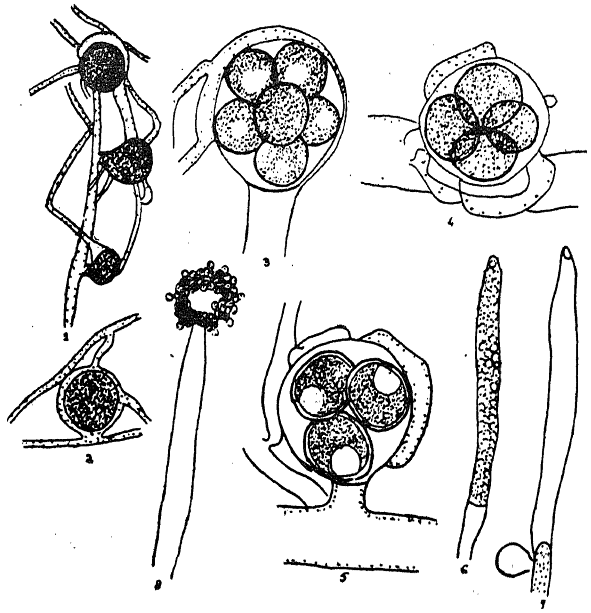

Plate 4. **Achlya aplanes.**

Fig. 1. A hypha with racemosely arranged Oogonia ×100.

„ 2. A young oogonium with a typical antheridial branch ×100.

„ 3. An oogonium containing six eggs ×400.

„ 4 & 5. Oogonia containing 4 and 3 mature eggs ×400.

„ 6. A typical mature sporangium ×100.

„ 7. A lateral oogonium just under an empty sporangium ×100.

„ 8. Sporangium with hollow cluster of spores at the tip ×100.

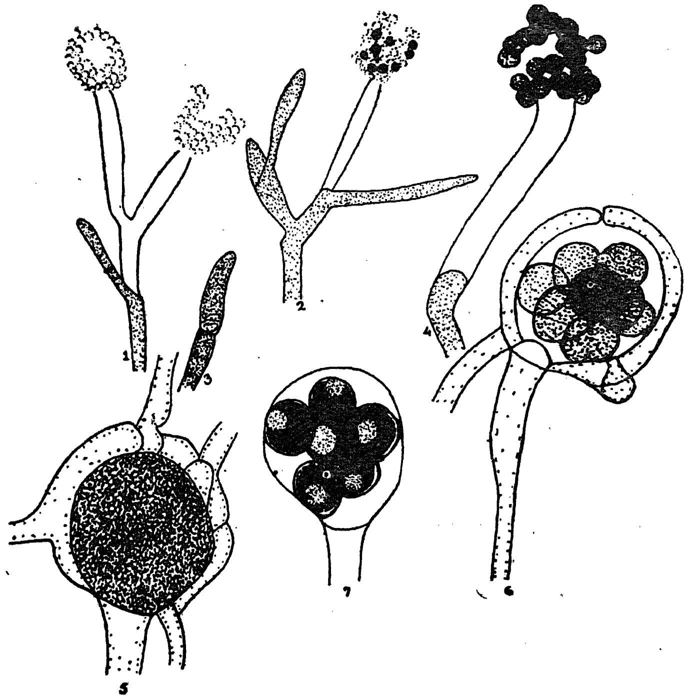

Plate 5. **Achlya flagellata.**

Fig. 1. Sporangia which have emptied $\times 100$.

„ 2. Sporangia showing empty cysts of the zoospores $\times 100$.

„ 3. Gemmae $\times 100$.

„ 4. Sporangium with hollow cluster of the spores at the tip $\times 400$.

„ 5. Oogonium showing diclinous antheridia $\times 400$.

„ 6. Oogonium with long stalk and eight eggs $\times 400$.

„ 7. Oogonium with ripe eccentric eggs $\times 400$.

Note.—All the drawings have been made by Camera Lucida and from living material.

Spores diplanetic, 9-14·5 μ in diameter, oogonia occassionally found in the culture, irregular, often seen in empty sporangia, intercalary or terminal, wall thin clourless, pits not visible. Antheridial branches diclinous, hyaline, delicate and quickly disappear, antheridia absent on most of the oogonia, usually few, laterally applied, not wrapping them about, eggs usually 1 to 8 or upto 16, centric, variable in size, 14-36 μ in diameter. Gemmae moderate, irregular.

These two species are reported for the first time from India. The diagrams and descriptions correspond closely to those given in Coker's monograph (1932).

Achlya aplanes Maurizio, Var. *indica*, Saksena & Dayal.

Growth vigorous on hemp seeds, main hyphae stout, usually ending in primary sporangia. Spores on leaving the sporangium come to rest at once in a hollow sphere, sporangia frequently retain the spores. If the spores emerge, they sprout at the mouth and in majority of the cultures theydo not have any swimming stage (a few swimming zoo-spores were always observed). Oogonia racemose on short stalks, terminal, spherical 54-126μ, wall smooth, fairly thick, without any pits. A young oogonium often proliferates to another and empties itself into it. Eggs 1 to 12, mostly 3 to 8, 27 to 45μ in diameter, eccentric, germination not observed. Antheridia diclinous, always wrapping about the oogonia. They generally proceed from more slender branches that run among the oogonial branches.

This species has already been reported by Chaudhuri & Kochhar (1935) from Amritsar and Gujranwala. The absence of the swimming stage of the zoospores is a characteristic feature of this plant, but this character has not been mentioned by the above authors. *Achlya aplanes* var. *indica* differs from the main species in the nature of the swimming stage of the zoospores. In the present case, the absence of the swimming stage was confirmed as described by Maurizio, but a few swimming zoospores were always observed. Since this does not agree with the American species, the author feels inclined to call it a new variety. The difference pointed out by the author has also been confirmed by Prof. Couch. In a personal communication to the author he wrote, "It is quite interesting to find that Maurizio's species is a valid one."

Achlya flagellata Coker.

On hemp seeds halves, the threads grow about one inch long and are about 108μ thick near the base and near about 18 to 36μ thick near the tip. Sporangia abundant, very variable in size 18—54μ × 108—666μ. Spores on leaving the sporangium, come to rest at once in a hollow sphere and encyst there. When they escape, they come out of their cysts and swim as usual. Spores 10 to 12μ in diameter. Gemmae abundant. Oogonia abundant, with projections. usually about 72—90μ, thick, borne laterally from the main hyphae, their stalks vary in length, wall hyaline (not thick), pits could not be seen. Eggs spherical, eccentric, 3 to 10 in an oogonium, mostly 3 to 7, 18 to 27μ in diameter, mostly 25μ. Antheridial branches abundant, usually much branched and irregular, more often diclinous than androgynous. Antheridia on nearly all oogonia, one to several.

It is reported from Amritsar, Lahore and Gujranwala and now from U. P. also.

Forms without Oogonia.

Achlya species No. 1.

Hyphae stout about 36—90μ, thick at the base and about 18—36μ near the tip, reaching a length of half an inch. Sporangia very abundant, of the typical *Achlya*

type, borne singly or in clusters on the ends of hyphae, varying much in shape from long, slender, tapering, varying from 666—900μ in length and 18—45μ, in width. Spores on leaving the sporangium, come to rest at once in a hollow sphere and encyst there. When the spores escape they emerge from their cysts and swim as usual. Spores 10 to 12μ in diameter. Gemmae few and like sporangium. Sex organs could not be induced.

Achlya species No. 2.

On a hemp seed half, the threads grow about one inch long and are about 54—90μ thick below to 18—45μ thick near the tip. The sporangia are plentiful and proliferate so as to form clusters. Sporangia cylindrical and about 18—54μ thick near the tip. The gemmae are oblong and sometimes in chains. Spores on leaving the sporangium come to rest at once in a hollow sphere and encyst there. When they come out, they emerge from their cysts and swim as usual. Spores 10 to 11μ in diameter. Sex organs could not be induced.

Acknowledgement.

The author takes this opportunity to express his gratitude to Dr. R. K. Saksena, Head of the Botany Department, University of Allahabad for his keen guidance and encouragement through out the course of investigation. His thanks are also due to Prof. J. N. Couch for kindly confirming the species and to Dr. B. B.S. Raizada of the Botany Department for his assistance.

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STUDIES ON TWO NEW SPECIES OF THE GENUS *ORIENTOCREADIUM* (TREMATODA : ALLOCREADIIDAE) FROM THE INTESTINE OF *CLARIAS MAGUR*

By

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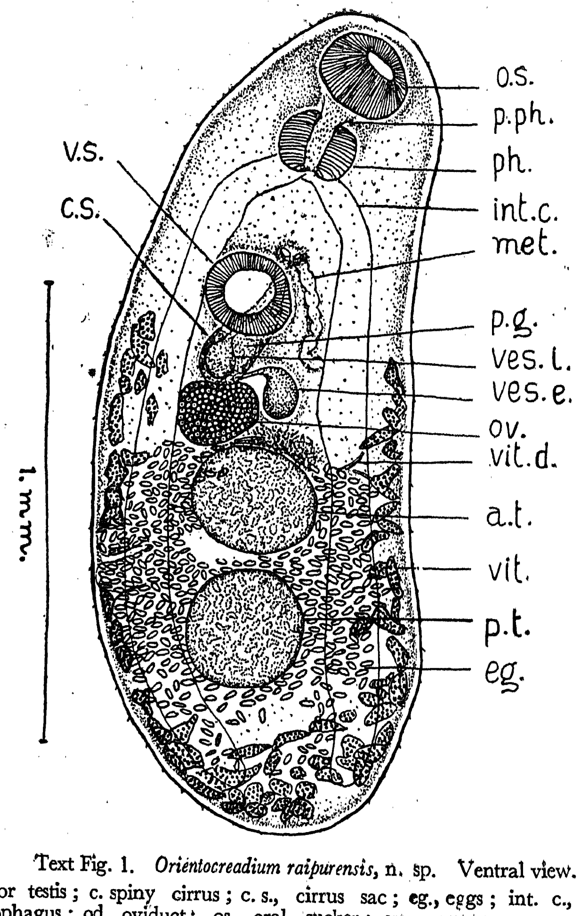
Department of Zoology, College of Science, Raipur, M. P.

Received on 5th August, 1957

INTRODUCTION

In this communication two new trematodes of the genus Orientocreadium viz. *O. raipurensis* n. sp. and *O. dayalai* n. sp. have been described and their systemati position discussed. They were obtained from the intestine of fresh water fish *Claria magur*. The work was carried out in the zoological laboratory of the College o Science, Raipur.



Text Fig. 1. *Orientocreadium raipurensis*, n. sp. Ventral view.

a. t., anterior testis; c. spiny cirrus; c. s., cirrus sac; eg., eggs; int. c., intestinal caeca; m metraterm; oe., ocsophagus: od. oviduct; os., oral sucker; ov., ovary; par., pars prostatica; p. g prostate gland, ph., pharynx; p. ph. prepharynx; p. t. posterior testis; ves. e., vesicula seminalis externa; ve i., vesicula seminalis interna; vit., vitelline glands; vit. d. vitelline duct; v. s. ventral sucker.

Orientocreadium raipurensis, n. sp.

It is a small spindle shaped trematode with rounded anterior and posterior ends. The body is 1·71 - 2·05 mm. long and 0·52 - 0·69 mm. broad at the region of the ovary. The cuticle is thin and is covered with minute backwardly directed spines.

The oral sucker is subterminal and almost circular in shape. It measures 0·17 - 0·21 × 0·21 mm. - 0·22 mm. The ventral sucker is approximately equal to the oral sucker. It lies at a distance of 0·45 – 0·55 mm. from the anterior end and measures 0·18 - 0·22 × 0·19 - 0·22 mm. The prepharynx is 0·04 - 0·06 mm. long and 0·04 - 0·05 mm. broad. It leads into a well developed pharynx which is 0·09 - 0·14 mm. long and 0·14 - 0·15 mm. broad. The oesophagus is very small. The intestinal bifurcation lies at a distance of 0·35 - 0·42 mm. from the anterior end. The caeca are simple in outline and extend upto the posterior margin of the body.

The excretory pore lies at the posterior end of the body and leads into a tubular bladder, which extends upto the level of posterior testis. The genital pore is situated in front of the acetabulum in the median line.

The two testes which are oval in shape, lie one behind the other in the posterior half of the body between the intestinal caeca. The anterior testis is situated at a distance of 0·88 - 1·13 mm. from the anterior end and measures 0·18 - 0·21 × 0·26 - 0·29 mm. The posterior testis, 0·21 - 0·24 × 0·26 - 0·3 mm. in size, is either in contact with the anterior testis or away from it, the distance between the two being 0·03 mm.

The cirrus sac is a long, slightly curved organ, lying in the median line (or slightly lateral), the anterior half of which is overlapped by the ventral sucker. The posterior margin of the cirrus sac is either in contact with the ovary or is overlapped by it. It is norrow in front and broad at the posterior end, measuring 0·26 - 0·39 mm. in length and 0·11 - 0·13 mm. in breadth at the region of the vesicula seminalis interna. It contains oval vesicula seminalis interna, tubular pars prostatica and the spiny cirrus. The vesicula seminalis externa is a retort shaped organ which lies on the left side of the ovary, extening upto its half level. It is 0·11 - 0·14 mm. long and 0·08 - 0·12 mm. broad. The vesicula seminalis interna measures 0·08 × 0·06 mm. A large number of prostate gland cells fill up the cirrus sac.

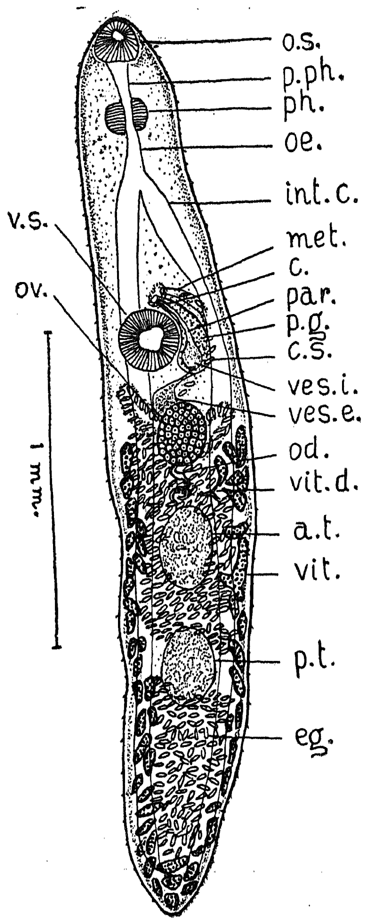
The ovary is bean shaped. It lies at a distance of 0·7 - 0·91 mm. from the anterior end, anterior to the testes, intercaecal in position and to the right side of median line. It measures 0·14 - 0·18 ×0·16—0·21 mm. and is either in contact with the anterior testis or keeps the distance of 0·06 mm. from it. The oviduct arises from the posterior margin of the ovary and opens at the ootype which lies above the anterior testis to the left of the median line. The receptaculum seminis is absent.

The vitelline glands consist of small follicles lying on the lateral sides of the intestinal caeca and partly covering them. They extend from the posterior margin of the acetabulum to the posterior end of the body, where they meet with each other and form a mass just behind the posterior testis. The transverse vitelline ducts lie above the anterior testis.

The uterus consists of transversely coiled descending and ascending limbs which covers the area from the posterior level of the ovary upto a certain distance behind the posterior testis. The ascending limb extends anteriorly on the left side of the acetabulum as a well developed metraterm which opens at the genital pore. The uterine eggs are oval in shape, and measure 0·024 - 0·03 mm. in length and 0·012— - 0·018 mm. in breadth.

Orientocreadium dayalai, n. sp.

It is a small spindle shaped trematode, measuring 2·77 mm. in length and 0·48 mm. in breadth at the level of the ovary. The body is covered with minute backwardly directed spines. The oral sucker is terminal. It is 0·13 mm. long and 0·15 mm. broad. The ventral sucker is larger than the oral sucker. It measures 0·195 × 0·19 mm. and lies at a distance of 0·88 mm. from the anterior end.



Text Fig. 2. *O-dayalai*, n. sp. Ventral view.

a. t., anterior testis; c. spiny cirrus; c. s., cirrus sac; eg., eggs; int. c., intestinal caeca; met. metratem; oe., ocsophagus: od.. oviduct; os., oral sucker; ov., evary; par., pars prostatic; p. g., prostate gland, ph., pharynx; p. ph. prepharynx; p. t. posterior testis; ves. e., vesicula seminalis externa; ves. i., vesicula seminalis interna; vit., vitellind glands; vit. d. vitelline duct; v. s. xentral suker.

The prepharynx is 0·09 mm. long. The muscular pharynx measures 0·1 × 0·13 mm. The oesophagus is 0·09 mm. long and the intestinal bifurcation lies at a distance of 0·43 mm. from the anterior end.

The excretory pore lies at the posterior end of the body. It leads into a tubular excretory bladder, which goes upto the posterior testis. The genital pore lies in front of the acetabulum in the median line.

There are two oval testes which lie one behind tbe other in the intercaecal space in the posterior half of the body. The anterior testis is located at a distance of 1·54 mm. from the anterior end. It is 0·22 mm. long and 0·21 mm. broad. The posterior testis is smaller than the anterior testis. It measures 0·225 × 0·165 mm. and the distance between the two testes is 0·1 mm.

The cirrus sac is a well developed curved organ, embracing the acetabulum on the left side upto its posterior margin. It is 0·285 mm. long and 0·12 mm. broad at the region of the vesicula seminalis interna. It contains vesicula seminalis interna, pars prostatica, prostate gland cells and the spiny cirrus. The vesicula seminalis interna measures 0·054 × 0·075 mm. The vesicula seminalis externa lies above the ovary on its right side. It is oval in shape and measures 0·12 × 0·09 mm. in size.

The ovary is oval in shape and lies vertically in a median line at a distance of 1·19 mm. from the anterior end. It is 0·18 mm. long and 0·15 mm. broad. The distance between the anterior testis and the ovary is 0·13 mm.

The vitelline glands are lateral in position. They extend from the middle level of the ovary to the posterior end of the body where they meet with each other. The transverse vitelline ducts lie above the anterior testis. The receptaculum seminis is absent. The laurers canal is present.

The uterus consists of transversely coiled ascending and descending limbs which extend from the region of the ovary upto the posterior end of the body. The eggs are oval in shape, measuring 0·024 – 0·027 × 0·015 mm. in size.

DISCUSSION

Orientocreadium raipurensis, n. sp. and *O. dayalai*, n. sp. differ from *O. batrachoides* in form and distribution of vitellaria which do not unite to form a lattice work, possession of oval vesicula seminalis interna, extension of cirrus sac and the genital pore being median. They differ from *O. pseudobagri* in relative size of suckers, posterior extension of vitellaria, and in the size of ovary which is smaller than the testes ; while in *O. dayalai* posterior testis is smaller than the anterior testis. *O. raipurensis* differs from *O. indicum* in oral and ventral suckers being equal, position and extension of cirrus sac and vesicula seminalis externa being retort shaped. *O. dayalai* differs from *O. indicum* in the extension of vitellaria, posterior testis smaller than anterior testis, prepharynx and oesophagus comparatively long, extension of cirrus sac and vesicula seminalis externa oval. The above differentiating characters lead to the creation of two species *Orientocreadium raipurensis* n. sp. and *O. dayalai* n. sp.

Yamaguti, 1953, has shown the genera *Neoganada* Dayal, 1938, *Ganada* Chatterji, 1933, and *Nizamia* Dayal, 1938, synonymous to the genus *Orientocreadium*. The generic characters of *Neoganada*, *Ganada* and *Nizamia* are identical to the genus *Orientocreadium* and whatever differences they show from each other and from the genus *Orientocreadium* are not sufficient to keep them separate and as such the similarity of the above genera to *Orientocreadium* shown by Yamaguti, 1953, is fully supported. Similarly the genus *Ganadotrema* Dayal, 1949, has striking similarity with the genus *Orientocreadium*. It has been separated from the genera *Ganada*, *Neoganada* and *Nizamia* on characters as spiny cirrus, shape of vesicula seminalis externa, shape of ovary and testes and on the presence or absence of receptaculum seminis. These differentiating characters are not sufficient to justify its ranking as a separate genus ; moreover its similarity with the genus *Orientocreadium* leads to the genus *Ganadotrema* synonymous to the genus *Orientocreadium*.

Thus the genus *Orientocreadium* includes all the species of the genera *Ganada, Neoganada, Nizamia* and *Ganadotrema* which have been shown synonymous to it. They are listed as below:

Geno-type: *O. batrachoides* Tubangui, 1931, in
Clarias batrachus; Luzon.

Other species:

O. Clariae (Chatterji, 1933) Yamaguti, 1953.
(Syn. *Ganada c.* C.) in *Clarias batrachus*; Burma.

O. indicum Pande, 1934, in *Rita buchanani*; India.

O. pseudobagri Yamaguti, 1934, in *Pseudobagrus aurantiacus*; Lake Biwa, Japan.

O. barabankiae (Dayal 1938) Yamaguti, 1953.
(Syn. *Neoganada b.* D.) in *Clarias batrachus*; India.

O. secunda (Dayal, 1949) (Syn. *Neoganadas.* D.)
in *Clupisoma garua*; India.

O. hyderabadi (Dayal, 1938) Yamaguti, 1953.
(Syn. *Nizamia h.* D.) in *ophiocephalus punctatus*;
India.

O. indica (Dayal 1949) (Syn. *Ganadotrema* i. D.) in
Heteropneustes fossilis; India.

O. mahendrai (Gupta 1951) (Syn. *Ganadotrema m.* G.)
in *Clarias batrachus*; India.

O. vermai (Gupta 1951) (Syn. *Ganadotrema v.* G.) in
Clarias batrachus; India.

O. phillipai (Gupta 1951) (Syn. *Ganadotrema p.* G.) in
ophiocephalus punctatus; India.

O. raipurensis, n. sp. *in Clarias magur*; India.

O. dayalai, n. sp. in *Clarias magur*; India.

Key to species of the genus *Orientocreadium* Tubangui, 1931 (Species of Synonymous genera included).

(A)	Vitelline follicles united to form a lattice work. ...	*O. batrachoides*
	Vitelline follicles do not unite to form a lattice work.	(B)
(B)	Vesicula seminalis externa divided into two parts	*O. hyderabadai*
	Vesicula seminalis externa undivided, tubular or sac like	(C)

(C)	Oral sucker larger than ventral sucker ...	(D)
	Oral sucker equal to ventral sucker ...	(E)
	Oral sucker smaller than ventral sucker ...	(F)
(D)	Vitellaria do not extend upto posterior end of body ...	*O. pseudobagri*
	Vitellaria extend upto posterior end of body where they meet with each other	1.
1.	Receptaculum seminis present	2.
	Receptaculum seminis absent	3.
2.	Testes lobed, vitellaria from level of acetabulum to posterior end of body	*O. barabankiae*
	Testes entire, vitellaria from level of ovary to posterior end of body	*O. secunda*
3.	Anterior testis larger than posterior testis ...	*O. mahendrai*
	Anterior testis smaller than posterior testis ...	4.
4.	Prepharynx long, ovary oval, vitelline glands unequal on two sides	*O. vermai*
	Prepharynx small, ovary bean shaped, vitelline glands equally distributed on both sides	*O. indica*
(E)	Cirrus sac median, posterior margin of which in contact with ovary or overlapped by it, genital pore median, vesicula seminalis externa smaller than ovary ...	*O. raipurensis* n. sp.
	Cirrus sac lateral, not extending upto ovary, genital pore submedian, vesicula seminalis externa larger than ovary	*O. phillipai*
(F)	Posterior testis smaller than anterior testis, vitellaria extend from middle level of ovary	*O. dayalai*, n. sp.
	Posterior testis larger than anterior testis, vitellaria extend from posterior level of acetabulum... ...	5.
5.	Cirrus sac median, dorsal to ventral sucker, genital pore lateral, vesicula seminalis externa sac like ...	*O. clariae*
	Cirrus sac lateral, genital pore median, vesicula seminalis externa tubular, coiled in appearance ...	*O. indicum*

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AGRONOMIC PRACTICES IN SOIL AND WATER CONSERVATION

By

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Read at the 27th Annual Session of the Academy held at the University of Jabalpur on 27th December 1957.

Introduction

Among the Agronomic practices designed to conserve soil and water and to increase crop yields, proper land use rank high. Benett (1939) while discussing soil conservation planning laid special stress on contour farming, strip cropping, judicious manuring, crop rotation, mulching, Ley farming, use of soil conditioners and grass water ways.

In this paper an attempt has been made to bring out the salient features of various agronomic practices and their role in soil and water conservation.

land Use Planning

Before any land is put to cultivation it is utmost important to see that the land is suitable for a particular type of crop and also the applicability of the method adopted in a general way. Normally it is seen that whenever land is opened for cultivation very little attention is paid to slope, soil and drainage conditions of the area. This affects a great deal in getting a successful soil conservation farming programme and therefore prior to putting any land under cultivation its capability to grow a particular food crop with its associated cultivation practices need be ascertained.

Contour Farming

Contour farming envisages all farming practices i.e. ploughing inter culture, etc., done along the contour. Each furrow cut across the slope acts like an obstruction to the running water, thereby retarding the run off and conserving soil and water, which finally results into increased crop production. In addition to this it saves fuel in case of power drawn implements and reduces drought power in case of bullock drawn implements.

Strip Cropping

This consists in dividing up large areas of sloping field or long down hill strips by putting in cross strips of any dense vegetation which will form an effective break to sheet washing during the period of destructive rainfall. Supplementary field crops such as clover, or a good hay making grass are good, and grain crops where these can be maintained in active growth during the rainy period. The above type of crops (close growing and erosion permitting) are planted in alternate strips. The

ratio being 1:3 or 1:5. In short the close growing strips act as filter for the run off from grain strips and thus reduces soil and water loss from the cultivated fields, the associated legume strips in addition to this helps in building up soil fertility.

Judicious manuring

Manures both organic and inorganic when applied to crops, result into better root development and close stand of the crop ; this not only helps in conserving the soil and water but also helps in progressive building up of soil fertility by incorporating increased quantity of organic matter i.e. by way of decomposition of crop roots into the soil.

Crop Rotation

Even the most primitive agriculture has some sort of crop rotation as its basis and all farmers are familier with the need for changing the crops grown on one piece of ground. Where the total crop production has an unduly large amount of erosive crops via, Maize-Potato-Tobaco for any catchment, every effort should be made to reach just a better balance by discouraging the excessive growing of erosion permitting crop. Non-erosive crops i.e. legumes, alfalfa, clovers etc. should be encouraged which in addition to the soil protective value will also act as soil improver with some fodder value.

Mulching

Mulching i.e shielding of surface soil helps in preserving physical structure of the soil and reducing loss of organic matter and plant nutrient from the soil erosion both by water and wind. This is particularly important in scarcity areas for it makes available increased amount of soil moisture to crops and assures higher yields. In addition to this it also reduces crop weed competition.

Ley Farming

Vast areas of marginal and submarginal lands which are progressively deteriorating due to unscientific land use can best be improved by ley farming by putting them under suitable grasses for a duration of 2 to 3 years and then bringing them back to cultivation in rotation. The grasses will improve structure of the soil and in addition would provide better feed to farm and village cattle.

Soil Conditioner

Recently many synthetic materials have been produced which when applied to degraded soils (viz lateritic soils, alkaline soils etc.) improve this structure and conseqently tilth. A few of them under the trade name "Krilium", Poly-ack, etc. may be used with reasonable hope of success for ameliorating structure of various degraded soils met with in this country and thereby putting them to better crop production.

Grass Waterways

During heavy rains, water from the fields find its way through small depressions or small drainage channels giving rise to rills and gullies. This is generally due to the lack of proper cross-section, location and management of these drainage channels—"Waterways". For safe water disposal it is necessary to design a suitable waterway depending upon the volume and velocity of the water and the type of soil. Sodding of these waterways with suitable grasses which are matty in

character and are capable of resuming their erect habit after the flow of the water has stopped. The management of these waterways is equally important. Manuring of grasses from time to time is important. Gaps when noticed should immediately be filled in with the same species of grass. No farm implements should be allowed to cross the waterways particularly when it is wet.

Conclusion

Using any one of the agronomic practices alone would undoubtedly increase to some extent the yields of your crops. Large amounts of fertilizers give high crop yields each year. Contour ploughing, seeding and cultivation will reduce the velocity of flowing water so that it will carry less soil and have more chance to soak in the ground.

But putting them all together large amounts, contour farming, strip cropping, rotation etc. each one helps the other. Bigger yields mean more crop residues to plough under. This increased residues and manure will imporve structure of the soil so that it will hold more water as a result of improved permeability. Legumes and grasses shield the soil against direct impact of rain-drops and in addition open the soil to make it a better "blotter", with it they can make better use of the plant food in the soil.

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ECOTYPIC DIFFERENTIATION IN SOME PLANTS OF VARANASI

By

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Read at the 27th Annual Session of the Academy held at the University of Jabalpur on 27th December 1957.

INTRODUCTION

Turesson (1922) introduced the concept of ecotypes, and its importance in the constitution and origin of species was soon recognised. He found that the differences observable in the field between populations of the same species occupying diverse habitats were maintained in the experimental garden, even when they are grown starting from seeds. He explained this as due to genotypical response of the plant species to a particular habitat. Since then a large number of ecotypes have been differentiated by many workers. A priliminary account of ecotypic differentiation in *Euphorbia hirta*, Linn., *Echinochloa colona*, Link., *Euphorbia thymifolia*, Linn., and *Setaria glauca*, Beauv., is given below :—

Pattern of ecotypic differentiation.

In *Euphorbia hirta*, two distinct populations are recognised in the field.

1. *Prostrate cushion type*—growing in dry hard soil subjected to trampling especially on foot paths (Plate I, Fig. 8).

2. *Erect type*—growing in moist localities. (Plate I, Fig. 7).

In Table I is given a Summary of field observations for these two forms mentioned above regarding habit of the plant, length of the leaf and length of the internode. Frequency distribution diagrams for these two forms as regards to length of the leaf and length of the internode is given in Figs. 1 and 2.

TABLE 1.

Euphorbia hirta—Measurements taken from field

Growth form	Mean height of the plant (Cm.)	Mean length of the leaf (5th node) (Cm.)	Mean length of the internode (5th) (Cm.)
1. Erect type	49·8 ± 10·51	2·45 ± 0·46	2·58 ± 0·67
2. Prostrate cushion type	...	0·98 ± 0·31	0·74 ± 0·26

Plate I. **Euphorbia hirta**

Fig. 7. *Erect type* growing in moist soil.
Fig. 8. *Prostrate cushion type* growing on foot path.
Fig. 9. *Prostrate type* obtained after culture experiment.
Fig. 10. *Erect type* obtained after culture experiment.

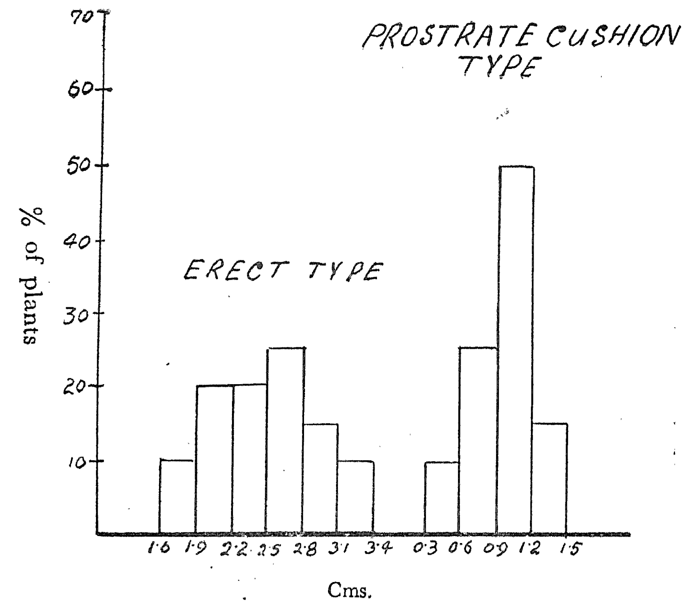


Fig. 1. Histogram giving length of the leaf (5th node) in cms. for *Euphorbia hirta.*

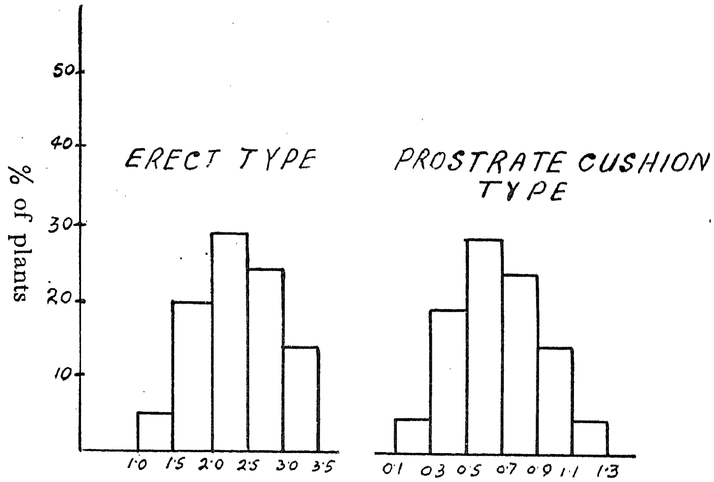


Fig. 2. Histogram giving length of the internode (5th) in cms. for *Euphorbia hirta.*

In order to know whether these two different forms are ecotypes or ecads only, young seedlings of both the forms were grown in the garden in two adjascent plots under similar conditions. It was found that the *erect type* maintained its habit, while the other one lost its cushion habit (Plate I, Figs. 9 and 10). A summary of observations regarding the two forms after transplanation is given in Table 2.

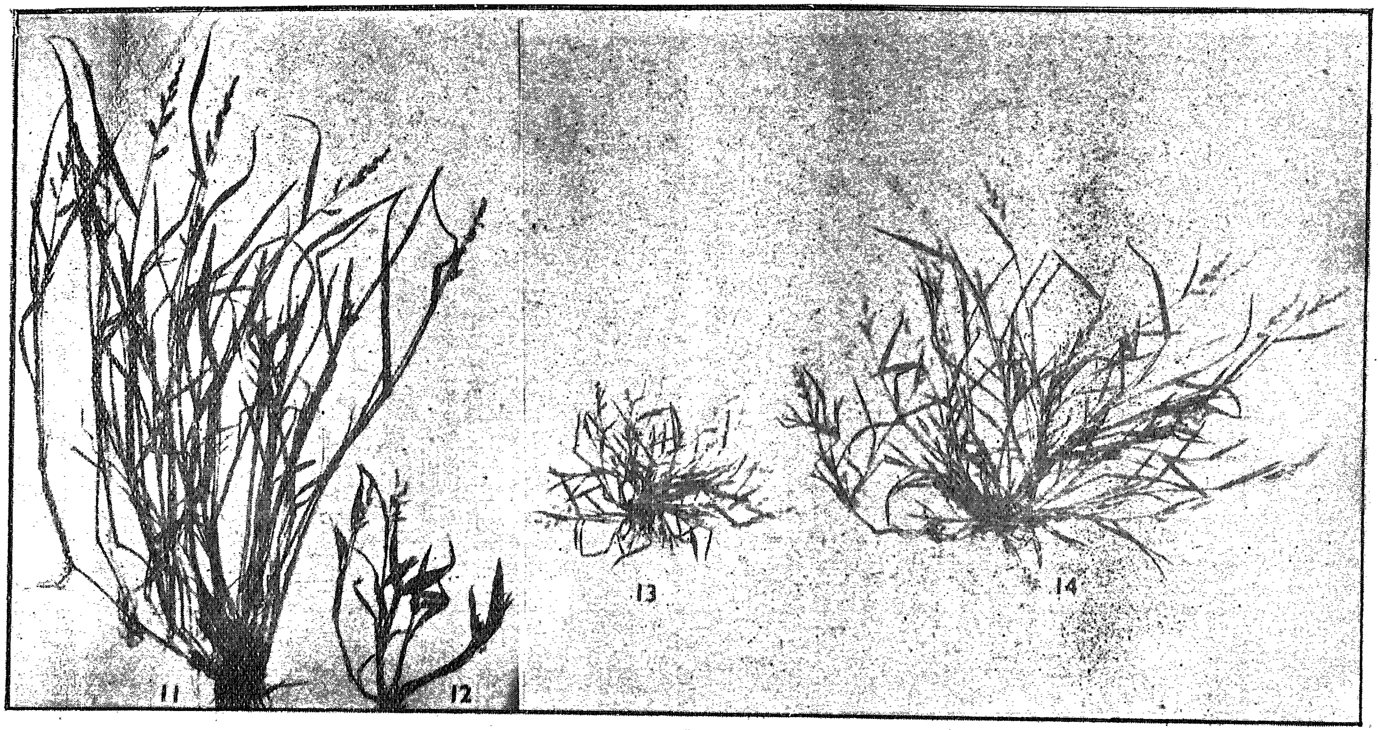


Plate II. **Echinochloa colona**

Fig. 11. *Tall form* growing in water-logged soil.
Fig. 12. *Short form* growing in drier localities.
Fig. 13. *Short form* obtained after culture experiment.
Fig. 14. *Tall form* obtained after culture experiment.

TABLE 2.

Euphorbia hirta—Measurements taken after culture experiment

Growth form	Mean height of the plant (Cm.)	Mean length of the leaf (5th node) (Cm.)	Mean length of the internode (5th) (Cm.)
1. Erect type	36·2 ± 4·68 ...	3·74 ± 0·44 ...	5·74 ± 1·07
2. Prostrate type	...	1·64 ± 0·24 ...	2·54 ± 0·85

Hence, it was suspected that there may be a third form—*Prostrate type* obtained in the garden, growing freely in nature. Thus two ecotypes and two ecads for one of the ecotypes are recognised.

Ecotype No. 1.—*Erect type*—growing in moist localities.

Ecotype No. 2.—(a) Ecad No. 1.—*Prostate type*—growing in dry hard soil.

(b) Ecad No. 2.—*Prostrate cushion type* derived from the above form under trampling on foot paths.

These observations are confirmed by growing these forms in a neutral substratum in the garden starting from seeds.

Similarly, two ecotypes have been differentiated in *Echinochloa colona*. These are found to be mainly related with the moisture conditions of the habitat.

Ecotype No. 1.—*Tall form*—growing in water logged soils, along the margin of shallow ponds and drainage channels (Plate II, Fig. 11).

Ecotype No. 2.—*Short form*—growing in comparatively drier localities (Plate II, Fig. 12).

The *Tall form* is found to have longer leaves, longer internodes and more vigorous growth as compared to the *short form*. A summary of data regarding these characters observed in the field are given in Table 3, and frequency distribution diagrams regarding the height of the plant, length of the leaf, and length of the internode is given in Figs. 3, 4 and 5.

TABLE 3.

Echinochloa colona—Measurements taken from field

Growth form	Mean height of the plant (Cm.)	Mean length of the leaf (Just below the inflorescence) (Cm.)	Mean length of the internode (Just below the inflorescence) (Cm.)
1. Tall form	51·35 ± 7·23 ...	10·13 ± 3·27 ...	9·005 ± 2·02
2. Short form	18·00 ± 5·03 ...	4·90 ± 1·54 ...	3·205 ± 0·99

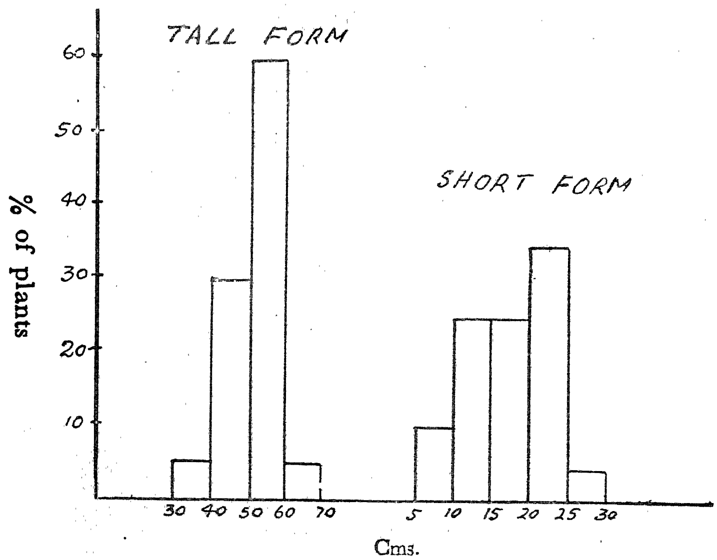


Fig. 3. Histogram giving height of the plant in cms. for *Echinochloa colona.*

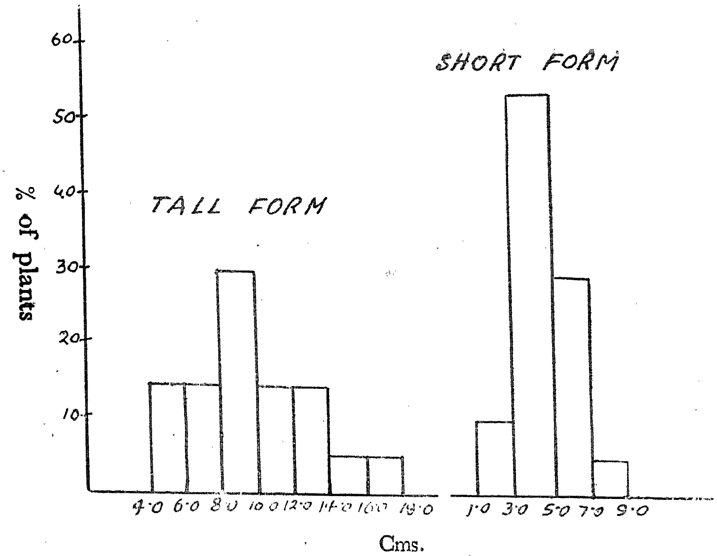
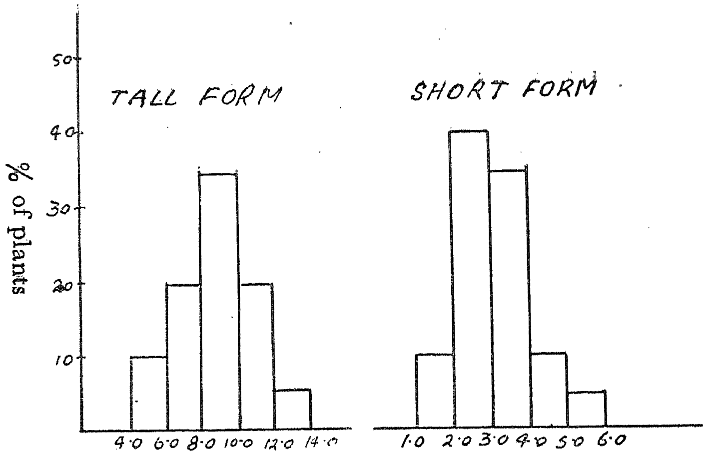


Fig. 4. Histogram giving length of the leaf (5th node) in cms. for *Echinochloa colona.*



Cms.

Fig. 5. Histogram giving length of the internode (5th) in cms. for *Echinochloa colona.*

Small segments (ramets) of both the above mentioned forms of *Echinochloa* grown in a neutral substratum in the culture garden maintained their original form when fully developed (Plate II, Figs. 13 and 14, Table 4).

TABLE 4

Echinochloa colona—Measurements taken after culture experiment

Growth form	Mean height of the plant (Cm.)	Mean length of the leaf (Just below the inflorescence) (Cm.)	Mean length of the internode (Just below the inflorescence) (Cm.)
1. Tall form	33·2 ± 3·42 ...	9·94 ± 2·24 ...	8·26 ± 1·32.
2. Short form	13·2 ± 1·15 ...	4·14 ± 0·55 ...	3·00 ± 0·71.

In *Euphorbia thymifolia,* two ecotypes are recognised in the field.

Ecotype No. 1—*Coppery Red form*—having a coppery red tinge throughout the plant body.

Ecotype No. 2.—*Green form.*

These two forms are distinct populations as shown by transplant experiments. The *Coppery red form* occurs either on soils rich in exchangeable calcium, or also on calcium poor soil in association with the *green form.* In other words, *coppery red form* can grow in localities where *green form* grows, but the reverse is controlled by the amount of calcium in the soil (Table 5). The two populations inter-breed. Further genecological work is in progress.

TABLE 5

Coppery Red form		Green form	
Exchangeable calcium in the soil.	Remarks	Exchangeable calcium in the soil	Remarks.
1. 84·35 m gm eq. %	Only coppery form growing	4·75 m gm eq. %	Only green form growing.
2. 30·10 „ „ „ „	„ „ „ „	10·50 „ „ „ „	Both green and coppery forms growing together.
3. 35·85 „ „ „ „	„ „ „ „	5·30 „ „ „ „	Only green form growing.
4. 10·00 „ „ „ „	Coppery form and green form growing together	8·40 „ „ „ „	Green and coppery forms growing together.
5. 8·40 „ „ „ „	Do.	4·50 „ „ „ „	Do.

In *Setaria glauca*—three different populations are recognised in the field (Plate III, Figs. 15, 16 and 17).

1. *Long panicled form*—growing in moist clayey soils.
2. *Short panicled form*—growing in dry loose, loamy, soils.
3. *Intermediate form*—growing on the tops of old walls and buildings.

Frequency distribution diagrams for these three forms regarding length of the panicle are given in Fig. 6.

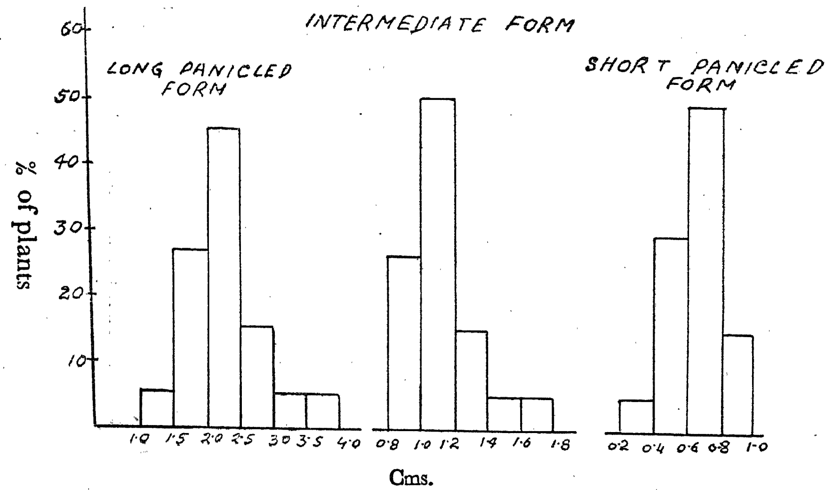


Fig. 6. Histogram giving length of the panicle in cms. for *Setaria glauca*.

Genecological work is in progress to reveal the nature of these different populations.

Acknowledgements :

My grateful thanks are due to Prof. R. Misra for his valuable guidance, constant encouragement and criticisms throughout the course of this investigation. Thanks are also due to Government of Uttar Pradesh for providing me with a Research assistantship which greatly facilitated the progress of the work.

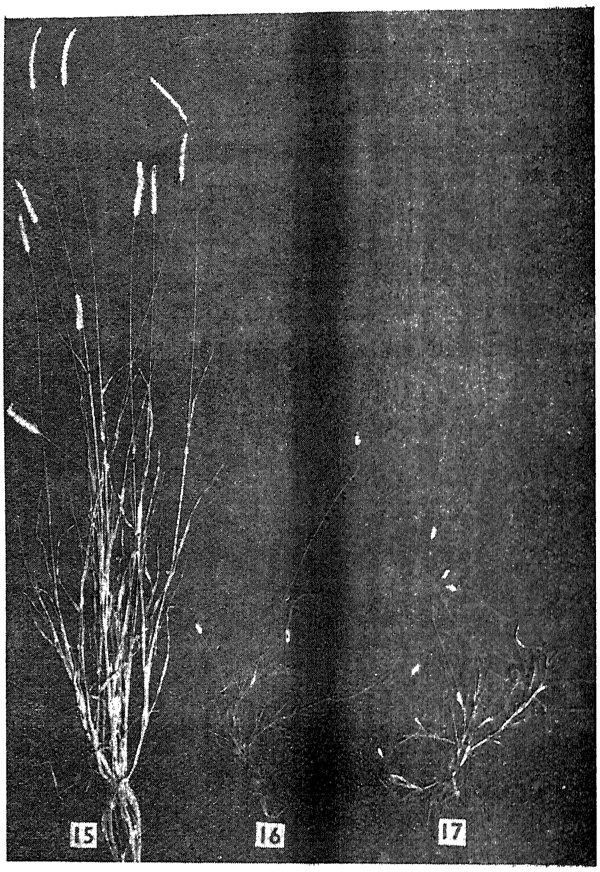


Plate III. **Setaria glauca**

Fig. 15. *Long panicled fcrm.*
Fig. 16. *Intermediate fcrm.*
Fig. 17. *S'ort panicled form.*

NOTES ON THE AUTECOLOGY OF *CROTALARIA MEDICAGINEA* LAMK

By

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Read at the 27th Annual Session of the Academy held at the University of Jabalpur on 27th December 1957.

Crotalaria medicaginea Lamk (Syn. *C. procumbens* Roxb.) is a common rainy season weed of Varanasi. It grows in the months of July-October on roadsides, enclosed gardens, hedges and sandy pasture lands known locally as Maechu, Thisi, Rayalbir, etc. In literature it is described as a perennial, but here it is found to behave as an annual plant.

It belongs to the family Leguminosae and sub-family Papilionaceae. The genus is very widely distributed and has 200-300 species (Hooker).

The species is described to have three varieties by Hooker :—

Var. 1 *hernianoides*

Var. 2 *neglecta*

Var. 3 *luxurians*

But Duthie includes the first in the second while Haines distinguishes only Var. *hernianoides* and *luxurians*.

Only the last variety Var. *luxurians* was found occuring in Banaras.

Geographic distribution

Very widely distributed in India, from the west Himalayas it extends to Ceylon and Burma, ascending to 6000 ft. in Kashmir. It has also been reported from Malaya Isles, Afghanistan, China and Australia.

Frequency of Stomata and Stomatal index.

Stomata are present both on upper as well as lower epidermis. But the density per unit area is always higher on the lower epidermis.

	Upper epidermis	Lower epidermis
Mean value for unit area ...	6·67	10

Again the density of stomata is greatest in very young leaves :

	Leaf next to the growing pt.	2nd	3rd	4th
No. of stomata per unit area ...	17·5	11·2	10·33	10
	14·6	13·6	10·4	10
	15	12	10	10

This is in agreement with the findings of Reed (1931), Yapp and Rea and Mall (1954).

The density was highest in the middle of the lamina, but lowest at the base.

Size of the stomata was found to be inversely proportional to the density:

	Apex	middle	Base
Mean No. of Stomate per unit area	9·625	10·33	8·4

Stomatal frequency

Upper surface	Lower surface
150–210	300–625

Stomatal frequency thus varies from 150-210 on the upper epidermis and 300-625 on lower surface.

The density of stomata is reduced slightly by shade:

	4th leaf from Apex	3rd	2nd	1st
Sun	10·4	9·6	13·6	17·5
Shade	9·8	10	10·96	17·2

Stomatal index varies from 30-21—34·04.

Seed out put:

	Ayurvedic gardens	Botanical gardens	Roadside
Average seed out pur ...	2678	1890	790

Ash content of the plant is very high 20-23·6%.

Seed germination:

Germination tests were carried out under normal conditions, total light, total darkness, different temperature treatments and buffer solutions of varying pH values.

Seeds germinated readily when kept for germination on the same day of collection and gave a high percentage. However in soil the percentage of germination was much lower.

	Soil	Under moist filter paper in petri dish
Percentage of germination	22	85

Seeds germinated in total darkness also. But the percentage was comparatively lower.

Temperature treatments.

Temperature is an important factor for germination. At room temperature (30°C) seeds germinate readily. Optimum temperature is 32°C. At 16°C there was no germination at all. Minimum is 20°C.

	Temperature				
Percentage of germination	16°C	20°C	24°C	32°C	35°C
	nil	15	18	88	20

When the testa was removed seeds germinated in 20 hours giving 100% germination while otherwise germination initiated on the 6th day.

Seeds sown in the soil on 8th Jan., 1956, failed to germinatc until 10th Feb., 1956. Probably temperature is the cause for this delay in initiation of germination. In the laboratory, however, when the seeds were kept under moist filter paper, germination started on the 9th day at room temperature (20°C). Percentage was very low.

Treatment with buffer solutions :

When germinated in buffer solutions of varying pH from 1-10, it was found that germination takes place only in neutral and alkaline media at pH 7-10. In all the other cases there was swelling of the seeds and breaking of the testa, but no radicle came out. At pH 10 the radicle appeared longer than those of untreated seeds.

Salt resistance :

Only Sodium chloride of different concentrations were tried.

No.	Conc. of the Nacl soln.	Temperature	Percentage of germination
1	2%	30	nil
2	1%	,,	,,
3	0·5%	,,	30
4	0·1%	,,	33
5	0·05%	,,	34
Distilled water		,,	62·3

Seeds lose their viability on storage. Thus seeds of the previous year gave only 4% germination under normal conditions, the rest when pounded in a mortar and kept for germination gave 30% germination.

The two forms:

The plant completes the life cycle by November. But in January a few plants come up which finish the life cycle by April. Thus two types of seasonal populations were found to occur:

1. Which comes up with the advent of monsoon i.e. by July, starts flowering and fruiting in August—September and finishes the life cycle by November.

2. Which comes up sometime in winter, survives the heat of March and dies away by April. Possibly this second form comes up with the winter rains.

GROWTH, ROOT NODULATION AND COMPOSITION OF BERSEEM AS INFLUENCED BY PHOSPHORUS AND CALCIUM APPLICATIONS

By

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(Received on 19th of February 1958)

INTRODUCTORY

The investigations, herein dealt with, primarily aim at evaluating the contribution that phosphorus and calcium make to the physiology of growth, root nodulation and nitrogen changes in the fodder legume, berseem (*Trifolium alexandrinum*), and the soil medium that supported the plants.

That legumes and nonlegumes respond differently to mineral nutrition is recognised yet the precise nature of their influence, in the case of the former, is in a rather confused state and no definite fertilizer practice has been worked out. Investigations on the gross mechanism of growth and nitrogen metabolism of legumes as related to phosphorus feeding by Wolkoff (1918), Fred *et al* (1932) and Eaton (1950) and of calcium feeding by Parker and Truog (1920), Burrel (1926), Burk (1927) alongwith Albrecht and associate (1929) have been attempted. Elaborating on the metabolism of legumes in respect of additives, Russell (1950) concluded that phosphorus enhanced root growth and hastend ripening process, while Trumble and Shapter (1937) stated that the protein content and yield of legumes depended mainly on phosphate dressings. In their review on "Phosphate Fertilization of Legumes" Sen and Rao (1953) concluded that an adequate supply of calcium and phosphorus was needed for nitrogen fixation. Hampton and Albrecht (1944) demonstrated with soybeans that calcium stimulated nitrogen fixation and increased vine growth, while Ginsburg and Shive (1926) reported that calcium had no apparent effect on protein content.

Wilson (1940) contended that the study on the effect of mineral elements upon nodulation, nitrogen fixation and growth has largely been emperical and throws little light on the metabolism of legumes. The nature, extent and significance of the influence of phosphorus and calcium nutrition of legumes, thus, remained obscure, and called for a critical examination of the foundation of our belief, especially in relation to the humus deficient neutral-alkaline Indian sub-tropical soils in contrast to the acidic soils where majority of work on this aspect has been conducted.

EXPERIMENTAL METHODOLOGY

Cultural : Pots containing approximately fourteen pounds of air-dry sieved field soil free from undecomposed plant residues and stone or brick pieces were taken for the purpose. Selected viable pure strain seeds of even absolute weight were sown in large numbers in each pot. Prior to the emergence of first leaf, the seedlings were thinned down to six equidistant plants in each pot; this number was maintained throughout. Fifteen pots were taken for the treatments *viz.*, superphos-

phate and calcium sulphate, each applied @ 40 lb/acre of P_2O_5 and CaO and the control with no addition. Of these, five pots from each treatment were set apart for growth studies. Sampling and chemical analyses were done, strictly at random, every tenth day from 30th day after gemination. The experimental plants were not subjected to foliar cuttings for fodder, in contrast to the prevelant practice, since, with the cutting of the top of the crop, several metabolic changes were induced in the plant as distinct from the normal (Singh, 1951) such that any comparison to evaluate the treatment effect would be vitiated. Wright (1920) also reported that if legume tops were removed the soil was depleted of nitrogen as effectively as if nonlegumes were grown and removed.

Growth, Yield and Biological Assessment: Visual observations of plant height, leaf count, branching and spread of assimilating leaves, along with dry matter elaborated by the plant, were assessed as growth index of berseem, in the presence and absence of phosphorus and calcium manuring, at successive growth stages during its ontogeny. Biological observations as to nodulation in roots (number and weight) were regularly recorded. All values are represented as average in the tables. Standard error and critical difference due to treatments have been computed and presented below each table as S. E. and C. D.

Chemical Composition: Total nitrogen was estimated after the method of Gunning and Hibbard for soils and Kjeldahl-salicylic acid method for plants (AOAC, 1945) phosphorus by Lorentz reagent method (Piper, 1944) and calcium by the oxalate method (Piper, 1944). Soil potassium was estimated by the K_2PtCl_6 precipitation method (AOAC, 1945).

RESULTS

Growth Behaviour: Growth of berseem, as measured by the visual observations of height, number of branches, number of leaves, alongwith dry matter formation of tops and roots, was distinctly benefitted by the application of phosphoric acid and calcium sulphate (Tables 1-9). The relative effect of phosphorus on all growth characters was more pronounced than calcium through the life-cycle of the plant. Phosphorus tended to increase plant height gradually till the attainment of maxima on the eightieth day; the increase effected being 3·85 inches over control and 1·95 inches over the calcium treated plants (Table 1).

TABLE 1

Influence of Phosphorus and Calcium Applications on Linear Growth of *Trifolium alexandrinum*

(As inches)

Age (days)	Control	Calcium	Phosphorus
30	2·23	2·31	2·44
40	5·40	5·43	5·58
50	7·45	8·08	8·68
60	8·33	10·05	10·96
70	10·77	11·72	12·67
80	11·95	13·85	15·80

S.E.=0·29 C.D.=0·9135

The efficiency of phosphorus and calcium on branching of berseem increased with age; branching commenced in all the series after forty days and could be virtually recorded on the fiftieth day. The trend of branching was almost alike except that phosphorus initiated and maintained superior branching than calcium; control plants possessed minimum number of branches throughout the life of the plants (Table 2.) Phosphorus, proved significiently better than calcium which in its turn, was superior to the control.

TABLE 2.

Influence of Phosphorus and Calcium Applications on Branching of *Trifolium alexandrinum* (number/plant)

Age (days)	Control	Calcium	Phosphorus
30	-	-	-
40	-	-	-
50	0·83	1·00	1·33
60	2·30	3·00	3·30
70	3·30	3·20	4·60
80	3·50	4·30	5·70

S. E. = 0·19 C. D. = 0·5985

There was to be noticed a considerably low increase in the branching of calcium treated berseem between the 60-70 day stage.

In leaf formation, again, phosphorus treated plants led the calcium series, though the latter remained a close competitor all through. The control set had significantly less number of leaves than the fertilizer fed plants; this superiority increased, evidently, with age (Table 3).

TABLE 3.

Influence of Phosphorus and Calcium Applications on Leaf Count of *Trifolium alexandrinum* (number/plant)

Age (days)	Control	Calcium	Phosphorus
30	2·3	2·5	2·8
40	5·0	5·7	6·3
50	11·3	12·3	13·4
60	15·3	18·7	20·8
70	21·6	26·8	26·9
80	26·7	31·5	34·6

S. E. = 0·63 C. D. = 1·9845

The effect of both phosphorus and calcium in increasing the assimilating leaf surface over the non-treated plants became specially evident after berseem had attained the age of 50 days.

The increase in the dry matter elaboration of tops was not much different upto the sixtieth day after which it was well marked in the fertilized plants as against the control (Table 4). Phosphorus proved significantly superior to calcium and the latter to the control.

TABLE 4.

Influence of Phosphorus and Calcium Applications on dry matter Accumulation of Tops of *Trifolium alexandrinum* (gm./plant.)

Age (days)	Control	Calcium	Phosphorus
30	0·009	0·013	0·014
40	0·039	0·048	0·052
50	0·078	0·083	0·093
60	0·126	0·131	0·142
70	0·170	0·178	0·198
80	0·213	0·233	0·251

S. E. = 0·0008   C. D. = 0·00036

This incidently, coincided with the period when the fertilizers showed relatively less increase in height. Between 60-70 days, phosphorus effected largest dry matter production, more than either calcium or control. The augmentation in dry matter increased with age.

In the growth and development of roots also the two additives proved superior to the control throughout the life cycle. Dry matter accumulation in the roots, however, failed to show any marked superiority of phosphorus or calcium although both proved slightly superior to the control (Table 5). The effect of minerals remained insignificant, findings in contrast to that reported by Russell (1950).

TABLE 5

Influence of Phosporus and Calcium Applications Dry matter Accumulation of Roots of *Trifolium alexandrinum* (gm./plant).

Age (days)	Control	Calcium	Phosphorus
30	0·0027	0·0034	0·0103
40	0·0070	0·0082	0·0242
50	0·0110	0·0132	0·0370
60	0·0241	0·0263	0·0775
70	0·0346	0·0370	0·1097
80	0·0554	0·0556	0·1670

Treatment effect insignificant.

Calcium treated plants exceeded phosphorus-fed ones in dry matter production o roots on the fifty-day stage after which a close run between the two was manifest.

Root Nodulation

The increase over control in the number of nodules in plants supplied with phosphorus was invariably greater than that in calcium treated ones. Till the fortieth day of the plant, phosphorus and calcium showed only insignificant difference which increased suddenly between 40-50 days and was maintained till the observation. The control plants, however, showed greater lack in nodule formation with the advance in age, except during the period 40-50 days (Table 6). Phosphorus treated plants showed significantly larger number of nodules than the control from the 40th day and in comparison to calcium treated ones from the 50th day. Calcium treatment proved significantly superior to the control from the 60th day only.

TABLE 6

Influence of Poshporus and Calcium Applications on Nodulation (Nodule Count) of *Trifolium alexandrinum*

(Average number per plant)

Age (days)	Control	Calcium	Phosphorus
30	19·7	22·0	24·6
40	26·3	37·2	39·2
50	37·4	42·8	51·5
60	39·6	50·2	57·8
70	45·3	59·6	68·6
80	52·0	69·7	80·4

S. E. = 1·8 C. D. = 5·670

The development of nodules as evidenced by their dry weight showed a close run in all the series, the response being in the order of P > Ca > control. At the end of fifty days the nodule mass increased rapidly, and the response to phosphorus in this regard was significantly more than that of calcium (Table 7).

TABLE 7.

Influence of Phosphorus and Calcium Applications on Nodular Development (Nodules' Dry Weight) in *Trifolium alexandrinum*

(gm./plant).

Age (days)	Control	Calcium	Phosphorus
30	0·0003	0·0004	0·0004
40	0·0006	0·0009	0·0017
50	0·0041	0·0054	0·0060
60	0·0063	0·0091	0·0113
70	0·0096	0·0121	0·0145
80	0·0114	0·0144	0·0248

S. E. = 0·0033 C. D. = 0·010395

Observations taken on the eightieth day after germination showed clearly that in phosphorus treated plants, the dry weight or nodule increased significantly.

Nitrogen Changes

In respect of superiority over control, in plant nitrogen (tops), phosphorus application appeared to maintain an increase over calcium treatment. On the 80-day stage the percentage of total nitrogen in tops of the phosphorus and calcium treated plants did not have much difference (Table 8).

TABLE 8

Influence of Phosphorus and Calcium Applications on Plant Nitrogen (Tops) in the case of *Trifolium alexandrinum*

(% nitrogen)

Age (days)	Control	Calcium	Phosphorus
30	0·0029	0·0046	0·0052
40	0·0078	0·0095	0·0110
50	0·0131	0·0155	0·1740
60	0·0194	0·0213	0·0234
70	0 0234	0·0256	0·0273
80	0·0248	0·0293	0·0304

S. E. =0·0122 C. D. 0·038430

The efficiency in respect of nitrogen percentage of the tops remained as P > Ca > control. Phosphorus proved significantly superior, only at certain stages, to control but never to calcium.

Roots of phosphorus fed plants possessed a higher percentage of total nitrogen as against those of calcium treated or control plants (Table 9).

TABLE 9

Influence of Phosphorus and Calcium Applications on Nitrogen Changes in Roots of *Trifolium alexandrinum*

(% nitrogen)

Age (days)	Control	Calcium	Phosphorus
30	0·0011	0·0015	0·0019
40	0·0026	0·0034	0·0040
50	0·0035	0·0046	0·0049
60	0·0064	0·0074	0·0087
70	0·0071	0·0059	0·0096
80	0·0085	0·0094	0·0112

S. E. = 0·00009 C. D. = 0·0002835

Phosphorus and calcium treatments exhibited significant increase over control for root nitrogen that appeared to diminish gradully with age. Nitrogent percentage of the roots showed a decline, with advance in age, in all the treatments. Taking the absolute values of nitrogen percentage in tops and roots of the plant, it was found that phosphorus, calcium and no-treatment could be arranged in the descending order as in the case of other characters.

Obeservations on the nitrogen status of the soil revealed that phosphorus was the most effective in increasing total nitrogen content of the soil as seen in the case of plant nitrogen as well, the beneficial effect of calcium was also well marked (Table 10).

TABLE 10

Soil nitrogen changes induced by Berseem Crop.

(Average in p. p.m., oven dry basis)

Pre-Crop Soil Nitrogen.	Post-harvest Soil Nitrogen		
	Treatments.		
	Control	Phosohorus	Calcium
514	530	552	547
Increase over initial value.	16	38	33

The effectiveness of berseem in increasing soil nitrogen was, however, fully confirmed as the nitrogen content increased in the control by 16 p. p.m. Collison and Mensching (1930) cited several instances where no benefit was accrued from legume growth in so far as the soil was concerned, the present findings stand in contradistinction. The soil nitrogen increased by 38, 33 and 16 p. p. m. in soils of the phosphorus, calcium, and control pots respectively, demonstrating the relative superiority of the two elements.

DISCUSSION

The results, reported herein, clearly demonstrated that phosphorus effectively enhanced, in general, the growth development and nodulation of the fodder legume. Increased growth of berseem has also been reported in a series of communications by Parr and Bose (1944, 1945) and by Sen and Bains (1951). The two additives behaved in an entirely different fashion when applied to grain legume (findings of the author with *moong* type 1, in course of publication). The superiority of phosphorus fed plants was consistently evident throughout the ontogeny of the legume, while the beneficial effects of calcium became more pronounced only in the subsequent developmental stages. It became evident that phosphorus and calcium treated berseem plants continued to have not only higher nitrogen percentage in the shoot as well as root than control but these also had larger numerical strength of nodules of larger nodule weight.

Phosphorus application increased both the nitrogen content of the soil as well as the foliage indicating, thereby that this element is closely connected with the

assimilation of carbohydrates through the leaves as well as nitrogen by the symbiotic action of *Rhizobia* and berseem. This fact is further supported by the author's findings (1942, 1951) showing an increase in the nitrogen percentage of the soil due to the excretions made by plants, high in nitrogen, through the roots.

Phosphorus and calcium applications not only succeeded in consistently increased growth of root nodules numerically but also in development of nodules, the former excelled the latter. The phosphate requirement of the berseem Crop was not satisfied by the quantity already present in the soil due possibly, to the phosphate being partially fixed owing to the lack of organic matter. Addition of superphos, a readily available source of phosphorus, augmented the growth of the crop, produced a nitrogen rich forage and also benefitted the soil by larger amount of nitrogen fixation. Phosphorus prompted better root growth (Table 5). Fibrous roots with more root hairs provided better chance of infection by *Rhizobium* as shown by Thoronton (1935) and Singh (1951), as supported by the number of nodules under different treatments (Table 6).

Calcium improved growth, nitrogen accumulation in the plant, nodulation and nodule development throughout the life cycle of berseem possibly by increasing carbohydrate content as indicated by increased dry matter accumulation. Evidence of increase in carbohydrate content by calcium has been quoted by Beeson (1941). Nitrogen accumulation was markedly augmented by dressings of phosphorus and calcium (Table 8). Of the two elements calcium equalled phosphorus in this respect at later stages of the growth of berseem which indicated that though both calcium and phosphorus had beneficial role on berseem, the feeding value of this fodder crop could well be increased by calcium manuring in sandy loam soils with an average nitrogen content of 516 p. p. m.

According to Parker and Truog (1920) this close relationship between calcium and nitrogen content in legume was due to the precipitation of acids formed as bye products in protein synthesis. Our soils in these parts of the state are known to be neutral with a tendency towards alkalinity and the effect of calcium sulphate may not be as reported by Fudge (1928), who attributed the beneficial effects of calcium to be due to its role in decreasing acidity and increasing availability of phosphorus. Calcium could not be, thus, regarded as a soil amendment or soil conditioner alone as stressed earlier by the author (1951) with the grain legume, *moong* Type 1. There is a possibilty that calcium sulphate behaved as a physiologically neutral salt and that, under the conditions of the experiment, there existed a great demand for the bases by the plant. It was demonstrated that for leguminous crops calcium appeared to have effect on the general growth of the plant, in the synthesis and hydrolysis of proteins and in some phases of carbohydrate metabolism, in addition to its effects on the activity of the *Rhizobia* (as shown by nodulation and nitrogen fixation). The explanation put forth by Albrecht (1940) that calcium applications proved beneficial since in calcium deficient soils phosphorus was lost from the plant diminishing its growth does not seem to be quite tenable under the conditions of the experiment as the CaO content of these soils was reasonably high (4082 p. p. m.) in addition to, 8579 p. p. m. of K_2O, 1045 p. p. m. of P_2O_5 and 514 of nitrogen. Though the soil was not limiting in either phosphorus or calcium yet their further application brought forth positive gains suggesting their role as a nutrient element.

SUMMARY

Importance of mineral nutrition of plants as a basic factor in determining productivity, yield and quality of produce, and nitrogen fixation by the legume is established, through randomised, replicated put culture experiments with *Trifolium alexandrinum*.

Phosphorus and calcium proved beneficial to the growth of berseem when applied singly @ 40 lb. per acre. The effect of phosphorus was more pronounced than that of calcium except that calcium treated plants exceeded phosphorus treated ones in dry matter accumulation of roots at 50 day stage.

Phosphorus increased nodulation, nodule number, fresh and dry weight of nodules. The order of effectiveness was as phosphorus > calcium > control throughout the period of observation.

A clear excess of accumulated nitragen in tops and roots, taken separately, was noticed under phosphorus treatment. Nitrogen percentage in the plant decreased with age irrespective of treatments. Berseem, when supplied with phosphorus, could increase soil nitrogen more than either calcium or control sets.

The practical application of this research is considerable. The rapid expansion of irrigation and the use of phosphorus dressings with the marked rise in productivity of the important berseem fodder, has clearly erected conditions that may effect soil fertility remarkably through the increased activity of the *Rhizobium* of the root nodules.

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EFFECT OF PHOTOPERIOD ON GROWTH, EAR EMERGENCE AND CARBOHYDRATE NITROGEN METABOLISM OF WHEAT

By

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Historical

The effect of relative length of day and night upon growth and reproduction in the plants has been studied since 1920 when Garner and Allard first directed the attention of plant physiologists towards the phenomenon of photoperiodism.

Fisher (1916) reported that vegetative condition in plants is characterised by a low Carbohydrate/Nitrogen ratio while the reproductive stage is characterised by a high ratio of these constituents. Kraus and Kraybill (1918) also found that Carbohydrate/Nitrogen ratio is an important determining factor for growth and differentiation. Likewise, Nightingale (1922) agreed in principle with the significance of C/N in plant production. Purvis (1934) worked on cereal plants under different day lengths with varying nitrate supply. She concluded that C/N ratio bears no causal relationship to the ability of a plant to differentiate flower initials or to produce flowers. According to Parker and Borthwick (1939), differences in chemical composition of plants did not seem to have any causal relationship to flower initiation. Murneek (1937) and Loehwing (1938, 1942) pointed out that carbohydrate-nitrogen changes in the plants are not fundamental to flower initiation.

Work on photoperiodism in India has mainly been directed towards studying the influence of different day-lengths on flowering. Mention may be made of the contributions of Alam (1940-41), Sircar (1942, 1944 and 1946), Pal and Murty (1941), Kar (1942-43), Sircar and Parija (1945), Saran (1945) and Mishra (1955). Some work has been carried out by Sircar and De (1948) on nitrogen metabolism as influenced by photoperiod. The present investigation was undertaken to throw light on the behaviour of carbohydrate and nitrogen fractions during the ontogenetic drift of the cereal plants when subjected to long photoperiods. Here an attempt has been made to understand the changes before and after the ear emergence.

Material and Method

Wheat variety R 9, an X-ray mutant of P 52 (Ranjan, 1940) was sown in manured experimental plots (60'×90') in uniform rows. The whole field was divided into two equal halves. One half was separated from the other one by a thick gunny bag barrier, and was given continuous light treatment of 24 hours duration using a dozen 100 watt electric lamps. The lamps were adjusted from time to time to maintain the distance of 2 ft. between the shoot tip of the plant and the source of light. Care was taken that the entire field area was uniformly illuminated. The lights were put on in the evening and were kept as such till day-break. Thus, arrangement was made to give 24 hours continuous light to the

plants throughout its life cycle. The other half of the experimental field was kept exactly under similar conditions except that no additional light was allowed to reach that area except the normal sun-shine.

Seeds of uniform size and weight were sown on Nov. 15, 1950, and the light treatment was given from Dec. 15, 1950. Fortnightly records on height of plants, tiller and leaf number were made at 5 stages during the life cycle of the plants. Twenty-five plants (5 rows, were selected at random and from each row 5 plants were labelled) were in each case used for observations. Chemical analysis of stem and leaf of both control and treated plants were also made along with growth records.

Starch, sucrose and hexose were determined using Somogyi's reagent (1945) while Kjeldhal's method was employed for the determination of total and soluble nitrogen (A.O.A.C., 1945). Method for determining amide nitrogen was adopted after Loomis and Shull (1937). All values have been expressed on fresh weight basis.

The first sampling of the plant was made just before the start of the light treatment, 20 days after germination when there was no distinction between the control and the treated ones. At the second stage, when 35 days old plants were sampled, there was no-marked differentiation between stem and leaf. During the next two stages 50 and 65 days old plants were analysed.

Experimental results

Plants under continuous light treatment showed ear emergence (in 50% cases) on 13th Jan., 1951 while control plants receving only normal day light flowered on 31st Jan., 1951. A difference of 18 days was, thus, observed in the time of ear emergence.

Height: Growth in length of the plants exhibited a different trend with increase in age due to light treatment (Table I). The height of treated plants was more than the control and it continued to be so upto 65 days after which control plants gained over the treated ones. The treatment effect was, however, significant at the 35 and 50 day stages.

TABLE I

Growth record of Wheat plant as affected by photoperiod.

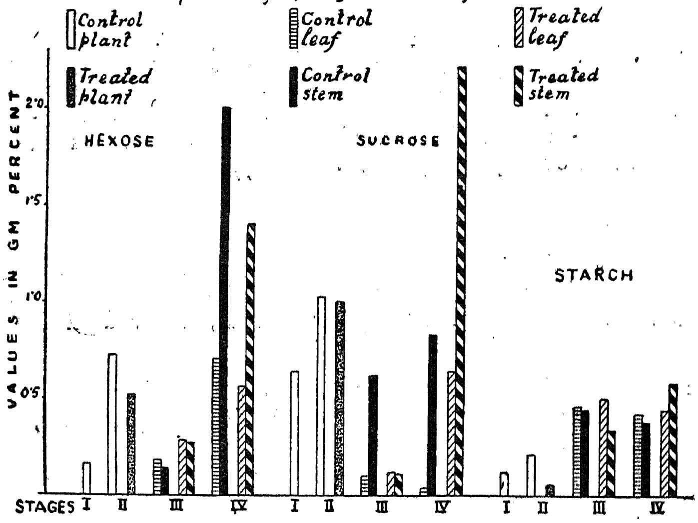
		Stages (age)					S. E. (due to treatment)	C. D.	
		I (20 days)	II (35 days)	III (50 days)	IV 65 days	V 80 days		5%	1%
Height (Cms)	Control	11·84	24·63	46·62	77·83	96·90	1·605	4·45	5·85
	Treated	13·12	31·79	67·13	77·31	77·42			
Tiller No.* (per plant)	Control	1·00	2·32	5·28	5·16	4·12	0·196	0·544	0·715
	Treated	1·00	1·24	2·48	3·96	3·88			
Leaf No.* (per plant)	Control	2·60	7·88	17·88	23·00	10·92	0·667	1·85	2·43
	Treated	2·68	6·88	8·16	11·32	2·56			

* Treatment effect highly significant.

Tiller number: Tiller number increased more rapidly in control than in treated ones in as much as that there was no significant difference between the control of second stage and the treated plants of third stage (Table I). Tiller and leaf number was more than double at 50 day stage in control plants as compared to treated ones.

Leaf number: The number of leaves per plant did not show significant difference between controls and the treated till the age of 35 days (Table I). However, at the third stage when plants were 50 days old a significant difference was observed. In the control plants, leaves increased rapidly and this trend was maintained throughout the life cycle. At the last stage, there was a fall in leaf number due to drying of the leaves.

Fig. 1 — Effect of photoperiod on hexose, sucrose and starch percentage of leaf and stem of wheat plant.



Carbohydrate: Hexose showed a rise at the second stage as compared to first (Fig. 1). At the third stage there was a fall in the values and it was more so in the control ones. At the final stage there was again a rise when controls showed much higher values than treated ones. There was practically no difference in the trend of values of leaf and stem.

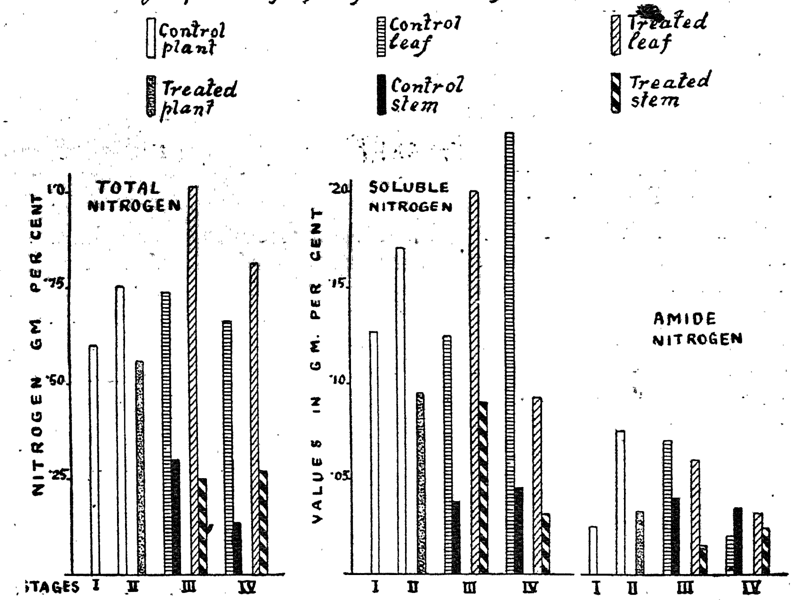
Sucrose also showed a rise at the second stage but there was no difference between the control and the treated. At the third stage there was steep fall in the values for leaves of both the control and the treated plants. In the case of stem, however, controls had a higher percentage of carbohydrate than the treated. At the final stage there was a considerable rise in carbohydrate, both in stem and leaves of the treated plants. The control plants showed a different trend. With increase in age the leaf showed a fall in carbohydrate from 35 days onwards while stem showed a fall upto 50 days, but again showed a rise in the end.

Starch exhibited a fall in the treated plants at the second stage as compared to first whereas the control showed but slight rise (Fig. 1). At the third stage there was a rise in the starch contents of both the stem and the leaf. A comprision of the control and treated plants showed that the leaf was charaterized with higher

values in the treated plants and reverse was the case in the stem fraction. At the final stage, the leaf values were almost the same in both the treated and the control plants, though in stem fraction, the treated showed higher percentage of starch as compared to control.

Nitrogen: Total nitrogen increased upto second stage in the control but afterwards there was a fall (Fig. 2). The decline with increase in the age was more pronounced in the stem than in the leaf. This fact did not hold good for the leaf of the treated plants where there was a rise upto the third stage followed by a fall.

Fig. 2 — Effect of photoperiod on total, soluble and amide nitrogen percentage of leaf and stem of wheat plant.



Total soluble nitrogen depicted the same trend in both leaf and stem except for the magnitude of difference which was more in leaf than in stem. The control showed a rise upto the second stage and then a fall was noticed. A rise was again recorded at the final stage. In the leaves it attained the maximum values at this stage. On the other hand leaves of the treated plants showed maximum value at the third stage, followed by a fall.

Amide nitrogen also showed a gradual fall after the second stage with minor fluctuations. It is seen that but for exception of leaf values at the final stage, the control plants always maintained higher percentage of amide nitrogen than the treated ones.

Discussion: The plants subjected to long-day photoperiod cut short their vegetative phase of life cycle to a great extent. From the very second stage of growth record, treated plants showed a reduction in tiller and leaf number as compared to control plants (Table I). The behaviour of wheat plant which is a long-day plant, towards a light treatment of 24 hours, showed that with prolonged light there was a reduction of vegetative growth. This is evident from the fact that the treated

plants at the third stage had only 8·16 leaves where as control plants at the same stage had 17·88 leaves. The ear emergence also took place 18 days earlier in the treated plants as compared to the control ones. This effect of reduction of vegetative growth and early flowering had also been reported by Sircar and Parija (1945) for winter variety rice.

In the treated plants there was a rapid increase in vertical growth in contrast to a reduction in the other growth characters. Control plants, which increased in height rather slowly, ultimately attained a greater height. Similar increase in height by prolonged light period has also been reported for several plants by Adams (1924). According to Garner, Bacon and Allard (1931) the elongation of the stem of summer radish resulted from long daily exposure to light along with an increased content of reducing sugars, particulary in the upper region of the stem.

Thus, treated plants were affected adversely as far as their vegetative characters are concerned, although they flowered 18 days ahead of the control plants. From the results it seems conclusive that by bringing about environment (light period only) favourable for reproductive phase of the plant's life cycle the entire vegetative phase is cut short. Similar findings have also been reported by Murneek (1937) and Loehwing (1938 and 1942). The food meant for better development of vegetative characters (leaf, tiller and height etc.) is rushed and sent for early ear emergence and seed production.

From the results it is seen that both leaf and stem of treated plants showed an increase in the monosaccharide fraction at the third stage when ear emergence took place. The disaccharides also revealed a similar trend but it is much less evident and that too only in the leaves. Starch which was less at the second stage in the treated plants (combined analysis of leaf and stem) increased at the third stage in the leaves. It, however, remained low in the stem at this stage but increased subsequently at the fourth stage.

From the results it is evident that there is a tendency for the carbohydrates in general and the monosaccharides in particular to increase at the time of ear emergence in the treated plants. These results support the findings of Kraus and Kraybill (1918), Nightingale (1922) and also of Gilbert (1926) who held that C/N ratio ascended as the plants approached maturity.

At the fourth stage when control plants flowered it was seen that the monosaccharide was more in both stem and leaf as compared to the treated plants. The disaccharide and the starch showed an increase in the treated plants at this stage. Thus, it seems that the formation and subsequent translocation of these comparatively stabler compounds to the grains had begun. Similar increase in amount of reducing sugars was apparent just before flower emergence in the experimental plants of Purvis (1934), but since this was preceeded by flower differentiation, it was regarded by her as a result rather than a cause of the onset of reproductive phase.

Total nitrogen showed a gradual decrease in the stem of control plants from the very second stage when plants were 35 days old and it continued upto the last stage (Fig. 2). Here it was seen that at the third stage control showed slightly more nitrogen than treated plants and at the fourth stage treated plants showed higher percentage of nitrogen as compared to control plants at the same stage. Thus, from these results it is evident that at the time of ear emergence there was less of total nitrogen and it rose later on for translocation to the grains which was evident from the treated plants. It may be that the nitrogen increases in the control plant after 65 days which cannot however, be confirmed as the analysis was not done after 65 days of growth.

The soluble nitrogen was also low in the treated plants at the second stage. There was an increase at the third stage in the leaves only, and again a fall at the last stage in both the leaf and stem. The stem value at the third stage was practically the same as at the second stage. Soluble nitrogen increased at the fourth sampling in the leaves of control plants when a decline was observed in the treated plants. From these results it seems to indicate that the inflow of soluble nitrogen must have been low before the time of ear emergence which is indicated by a low value of total nitrogen. No doubt an increase in the soluble nitrogen had been observed at the time of ear emergence but this is an indication of an increase in total nitrogen level in future. It has got to increase to supply the protein nitrogen for seed formation. The low values of total nitrogen at the time of ear emergence indicated that the amount of insoluble nitrogen required at and before the time of ear emergence was low but it increased afterwards. These results are in confirmation with the findings of Kraus and Kraybill (1918), Nightingale (1922) and others, that at the time of ear emergence a high C/N ratio exists. Nightingale has expressed the opinion that the significant ratio in growth is that of Carbohydrate/insoluble nitrogen, since accumulated nitrate did not effect flowering.

Amide nitrogen remained low in the treated plants throughout as compared with its corrosponding control. This was true of both the stem and the leaf (especially that of stem). This supression of amides at all the stages till the third sampling is simply confirming the above statement that the production of protein nitrogen has been lowered in the treated plants (due to light effect). It increased only at the time of seed formation. A slight increase in amide nitrogen had been observed at the last stage in the treated plants.

Conclusion

From the foregoing discussion the following facts are evident: For a long-day plant like wheat, a long photoperiod forces early ear emergence coupled with a marked reduction in the vegetative growth attributes (including leaf and tiller number and plant height).

Along with the effect on morphological characters, carbohydrate and nitrogen fractions were also affected. Carbohydrates including hexose and starch showed an increase at the time of ear emergence and thereafter a decline. Nitrogen decreased at the time of ear emergence. This decrease in nitrogen percentage and an increase in sugars was brought about by the extra light supplied to the plants. Thus a high carbohydrate/nitrogen fraction was associated with the ear emergence. The increase in nitrogen (especially the soluble forms) after the ear emergence in both the treated and cantrol plants seemed to be due to translocation to the developing grains.

Summary

1. Wheat var. R9 was sown in the field and one half of the plot was given light treatment of 24 hours duration after one month from the date of sowing.
2. A record of height, tiller number and leaf number was taken at five fortnightly intervals during the life cycle of the plants. At these very stages chemical analysis of stem and leaf of both control and treated plants were also done of the various fractions of carbohydrate and nitrogen.
3. The plants receiving continious light showed ear emergenc 18 days earlier as compared to control plants receiving normal day light.
4. The trend in growth and carbohydrate nitrogen fractions at different stages have been described in details in the text.

5. The effect of light treatment on growth and carbohydrate and nitrogen metabolism throughout the life cycle of the wheat plant has been discussed in details.

6. It seems that for long day plant like wheat, long day photoperiod brings about early ear emergence and a reduction in the vegetative growth characters. Carbohydrate and nitrogen fractions were also affected. A high C/N ratio was associated with the ear emergence.

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